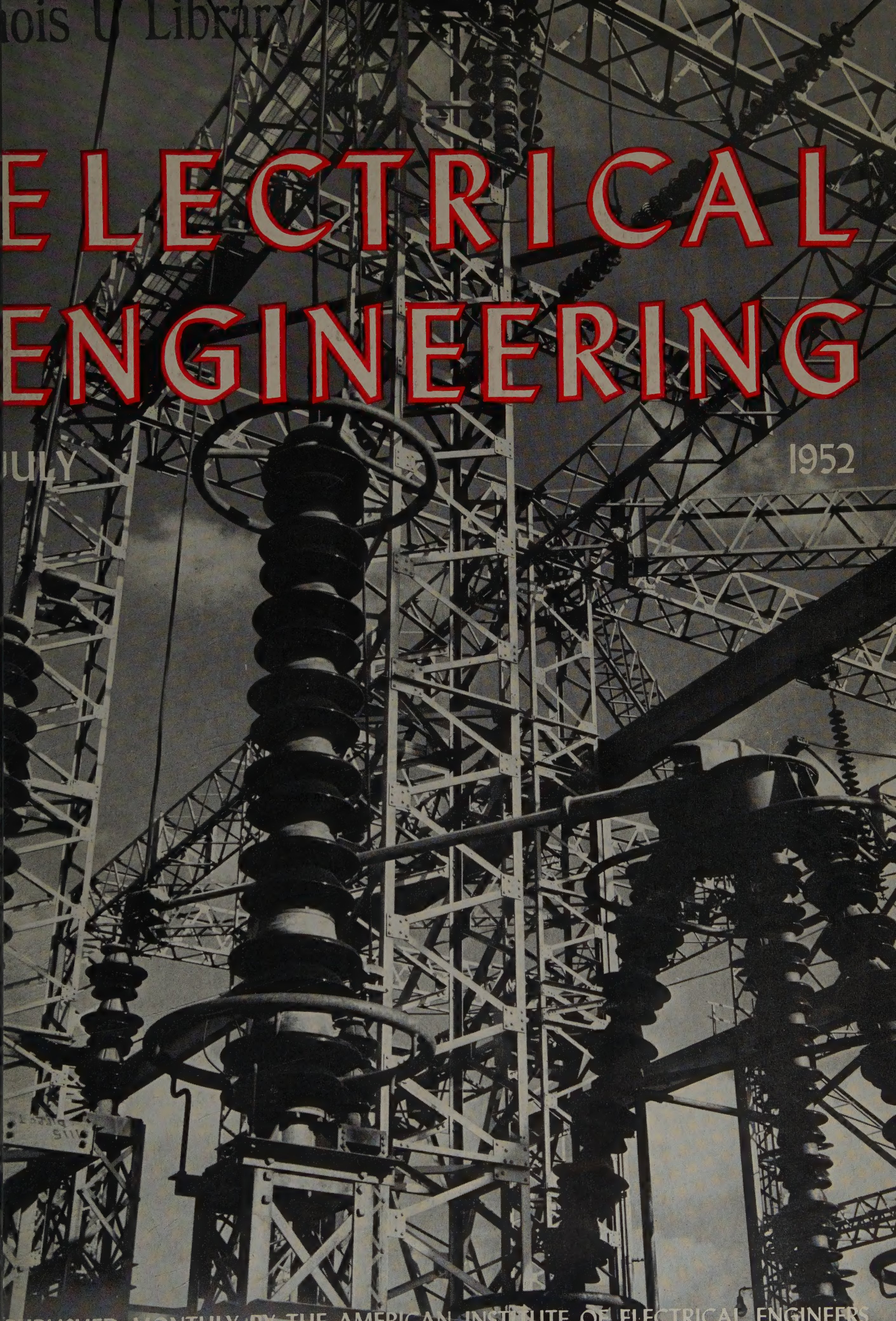
# ELECTRICAL ENGINEERING

JULY 1952

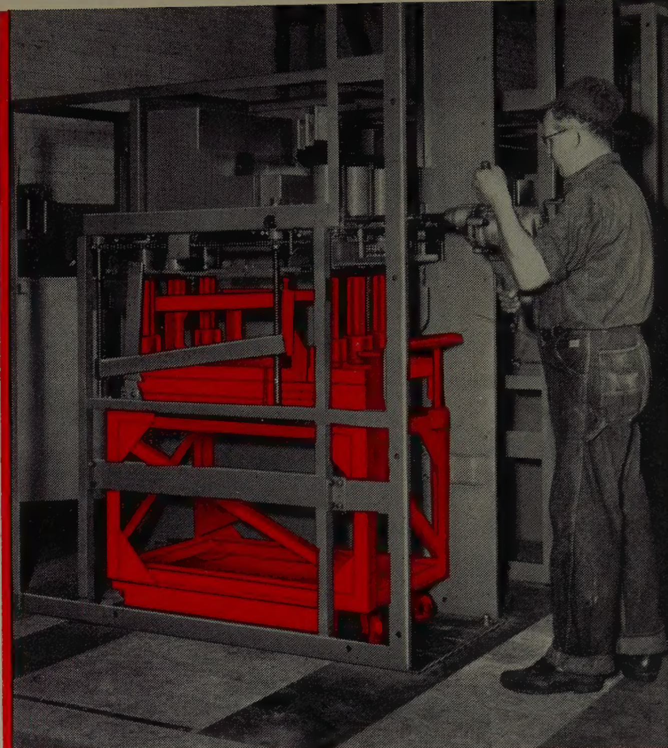


PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

★ EVERY CIRCUIT BREAKER

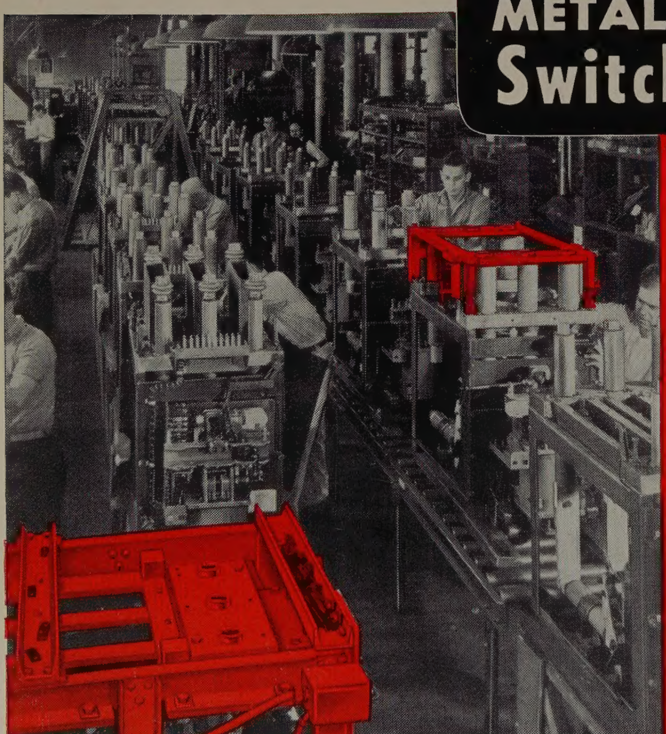
★ EVERY STATIONARY ELEMENT

# ...Built to Master Jigs!



Perfect alignment of all parts is assured by jigs. Master jig of removable element is shown inside stationary element. Operation of elevating mechanism also checked with this same jig.

## ALLIS-CHALMERS METAL-CLAD Switchgear



A number of jigs are used in building the removable elements. Two are shown in circuit breaker assembly line. This care during manufacture pays off in ease of installation.

## For Fast, Easy Installation... Interchangeability Between Units of Same Rating

THIS IS JUST one example of the care taken ir manufacturing Allis-Chalmers switchgear Every step in building, every detail of construction receives this same careful attention. It will pay you to find out more about Allis-Chalmers switch gear. Call your nearby Allis-Chalmers Distric Office for complete information, or write Allis Chalmers, Milwaukee 1, Wisconsin.

A-373

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First in the U. S. with Metal-Clad Switchgear

# ELECTRICAL ENGINEERING

Registered United States Patent Office

JULY
1952


**The Cover:** One of the horizontal rotating switches used to select the five taps of the high-voltage winding of the power transformer at the new General Electric high-capacity switchgear development laboratory near Philadelphia, Pa. (See article in this issue, pages 608–14.)



Statements and opinions given in articles appearing in ELECTRICAL ENGINEERING are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the


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Associate Editor

F. A. Norris
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J. S. Lopes
Advertising Director

VOL. 71 NO. 7

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

Headquarters
33 West 39th Street
New York 18, N. Y.

Editorial Offices
500 Fifth Avenue
New York 36, N. Y.

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# HIGHLIGHTS........

**Recent Conferences.** Two highly successful conferences in which the AIEE participated were held during May. The Southern Conference on Electrical Application for the Textile Industry met in Atlanta, Ga., at the A. French Textile School and lasted for two days (*pages 658–9*). The second, a symposium on "Progress in Quality Electronic Components," had more than 1,000 engineers and technical authorities in attendance. It was held in Washington, D. C. (*pages 653–7*).

**Unity of the Engineering Profession.** As the latest step toward unity of engineers, the Exploratory Group to Consider the Increased Unity of the Engineering Profession has proposed a plan which would involve the expansion of Engineers Joint Council. To orient the reader, *Electrical Engineering* presents the full report of the Exploratory Group and a brief résumé of its background (*pages 588–94*).

**Engineer and Defense Mobilization.** In this behind-the-scenes report, AIEE Past-President Fairman recounts some of his experiences as an engineer among the politicians and bureaucrats in Washington. As a result of his year as Defense Electric Power Administrator, he urges every engineer to support our mobilization program; by preparing now we may yet avoid another war (*pages 583–7*).

**Tomorrow's Engineer.** The quantity and quality of our future supply of engineers is the subject of two articles in this issue. In his consideration of tomorrow's engineer in preparation, K. B. McEachron, Jr., points out that we must interest our young people in science at an early age if we hope to find among them the engineers of the future. Also, we can improve the calibre of the engineering graduate by further improving technical education at the college level (*pages 597–602*). Guy Kleis takes us a step further in his discussion of tomorrow's engineer in use, in which he shows us how to use the supply of engineers more efficiently. He emphasizes the importance of industrial training programs and continued education at the graduate level (*pages 603–05*).

**Aircraft Intermittent Electrical Faults.** The two kinds of aircraft electrical faults are described and the intermittent type investigated here. Many light-contact line-to-ground faults were studied in simulated 30-volt d-c, 120-volt d-c, and 120/208-volt 400-cycle a-c systems. Methods of obtaining complete and limited protection from faults are also presented (*pages 643–9*).

**Wind Tunnel Drive Control.** A control, which reduces the initial cost considerably below that of a plain liquid rheostat control while sacrificing only some operating efficiency, and is of the conventional Kraemer type, is described (*pages 648–50*).

**Series Generator—Shunt Motor Oscillator.** "Galloping Gertie," as this unusual oscillator is nicknamed, is examined in terms of circuit analysis. The results show the close relationship between analysis and test for this type of circuit (*pages 639–41*).

**Germanium.** The basic characteristics and limitations of this semiconductor are described to provide engineers with the data necessary to an appreciation of its industrial uses (*pages 619–25*).

**High-Capacity Switchgear Development Laboratory.** This new installation includes the two largest generators yet built for short-circuit testing. These 1,800-rpm generators, each nominally rated 125,000 kva, can be operated in parallel, or each can test different equipments simultaneously (*pages 608–14*).

**Nonstrategic New Permanent-Magnet Material.** This barium compound has mechanical properties much like the ferrites, while its specific gravity is about 4.5 as against 7.5 for most magnet steels. It also has a high stability in the face of demagnitizing influences which recommends it for use in motors and generators in which the air gap is frequently changed (*pages 644–7*).

**Carrier Telegraph System for Short-Haul Applications.** This new system was developed especially to fulfill the requirements of less populated areas. Although more complex and expensive than amplitude modulation, frequency-shift operation was chosen chiefly because of its advantage for handling Teletypewriter Exchange Service supervisory signals (*pages 625–30*).

**Linear Circuit Theory and Servomechanism Design.** The problems in this field as seen by a design engineer are set forth, and a plea for closer liasion between designers and researchers is made (*pages 614–15*).

**Experiences With Diesel-Electric Locomotives.** Five years of operation with diesel-electrics on the Missouri-Kansas-Texas Railroad has revealed certain operating difficulties. Some of these, not ascertainable in usual shop tests, were revealed by a car especially equipped for on-the-road testing (*pages 650–2*).

## News Index



### AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

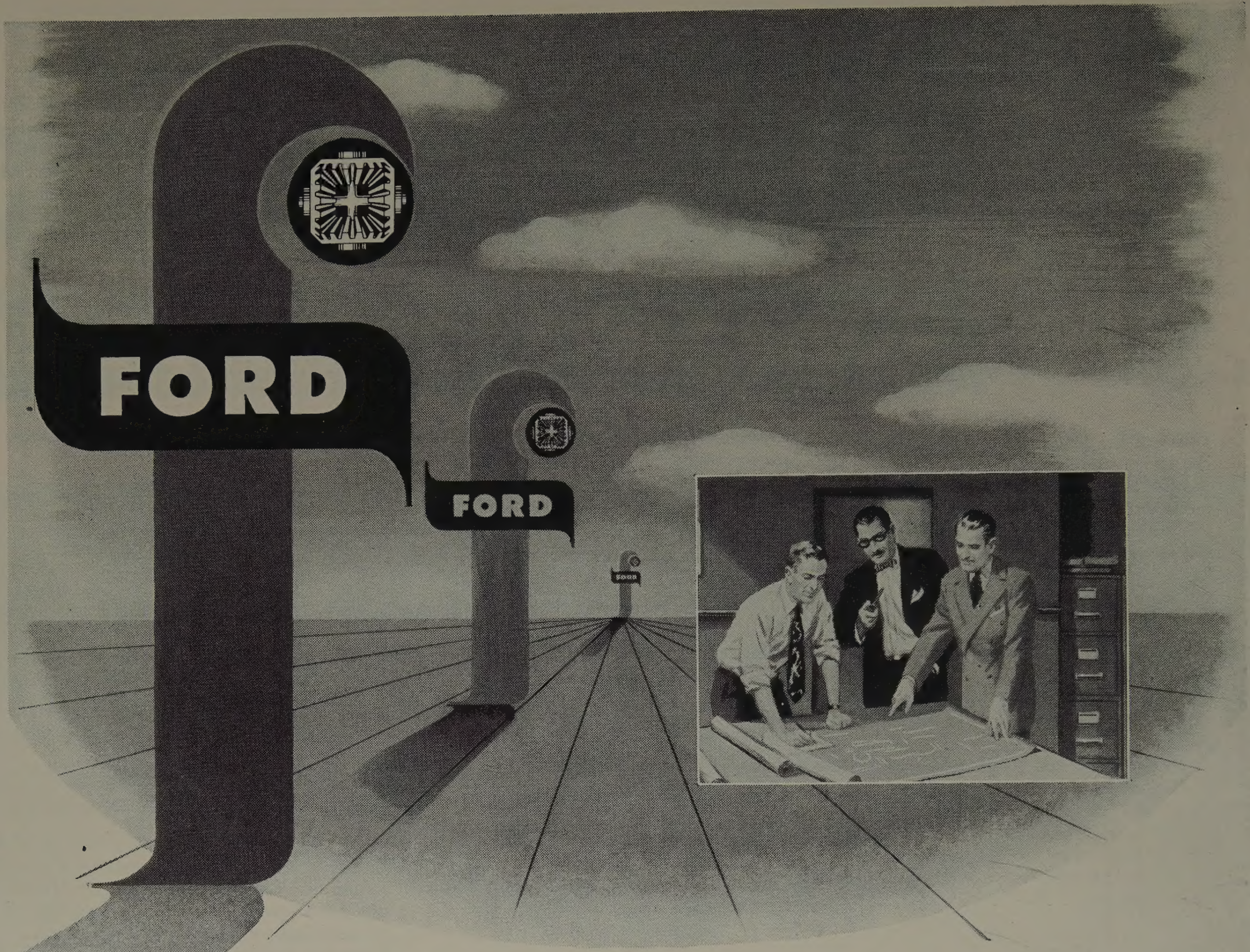
AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Affiliates, Associate Members, Members, and Fellows.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

| Location of Order Forms | Meetings Covered |
|---|---|
| Mar '51, p. 35A | Winter General |
| July '51, p. 23A | Southern District; North Eastern District; Great Lakes District; Summer General |
| Nov '51, p. 37A | Pacific General; Fall General |
| May '52, p. 37A | North Eastern District; South West District |

**Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.**


ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 36, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. July 1952, Vol. 71, No. 7. Number of copies of this issue 52,400

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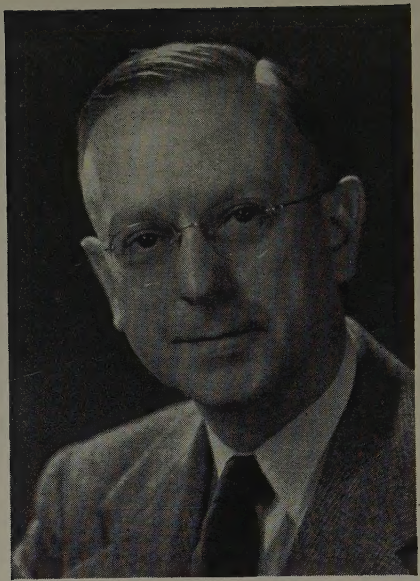
# The Engineer's Role in Defense Mobilization



J. F. FAIRMAN
FELLOW AIEE

**As Defense Electric Power Administrator, Past AIEE President Fairman has been able to observe at first hand the problems of government administration, particularly in regard to our defense plans. He urges every engineer to support the present mobilization program because, by preparing for hostilities before they start, we may be strong enough to avert war.**

ABOUT 10 MONTHS AGO, I sat down in a well-upholstered chair in a comfortable air-conditioned office in the Department of the Interior Building in Washington, D. C. The name plate on the door said that I was the Administrator of the Defense Electric Power Administration. The organization chart said that my boss was the Secretary of the Interior, a member of the President's Cabinet.

There I was, an engineer, among the politicians and the bureaucrats.

I have been a college professor, electrical engineer for a big electrical utility, and a utility vice-president. This was my first experience in government. I have found out that there is more in Washington than cherry blossoms. I have also found out that there is more in government for the engineer to think about than the criticisms of government which are to be found in almost every newspaper and magazine.

Let me tell you a few of my experiences. I begin, of course, with the thing without which no story of Washington is complete today: investigations. In the great wave of investigations, from Kefauver to Newbold Morris, we were not forgotten. The Defense Electric Power Administration has been looked into by the Maybank Committee of the Congress, perhaps better known as the "watchdog committee." In a 100-page booklet published on January 15 of this year, they reported their findings. Having learned from some of the masters in Washington how to pick the right sections to quote, I quote from page 15 of their report:

"It has heartened your Committee that no charges of impropriety or ineptitude were hurled against those in whose hands administration of this program rests. Your Committee cannot help but believe that this is a valid indication of a program generally well-conducted. It is refreshing to see such a demonstration of co-operation in the national interest among men holding widely diverse views as to the best method for operation of the electric power industry."

In addition to the Maybank Committee, the Celler Committee, headed by Emanuel Celler, Representative from New York, made an investigation of people like me serving the Government without compensation, and reported that we were very devoted and selfless public servants, rising above our special interests to serve the government faithfully.

I hope that these two carefully selected endorsements will convince you that after a year of duty amid the temptations of Washington, I remain in the Ivory Soap class—99.44 per cent pure.

## THE BUDGET PROBLEM

FROM INVESTIGATIONS, I now turn to what is obviously the next subject: money. The Federal Government this year expects to spend about $461 for each man, woman, and child in the country. My responsibility has been to spend wisely what 2,500 people chip in. To run our little agency of less than 200 people for a year, we needed $1,250,000.

Let me tell you what happened when I tried to get the money.

First, I had to go to the Bureau of the Budget, a very powerful agency in Washington which scrutinizes all proposed expenditures. I told them what our needs were. They sent people over to look at our operations and then recommended that we be given $1,000,000. That was

Full text of an address presented at the AIEE North Eastern District Meeting, Binghamton, N. Y., April 30-May 2, 1952.

J. F. Fairman, Administrator, Defense Electric Power Administration, Washington, D. C., is a past president of the AIEE.

a cut of $250,000. The President included this amount in his recommendations to the Congress.

Next, the House Appropriations Committee set a date for a hearing, and called upon me to testify. I found that the Representatives were seriously interested in what we were doing and I tried to answer their questions clearly and frankly. After they were through with their deliberations, they recommended that we be cut another $250,000. I added it up and found that, after talking twice, I was out $500,000.

Our appropriation then went to the floor of the House of Representatives, and they voted that we be given no funds. They did not want to put us out of business so they said that the Secretary of the Interior should reach down in one of his other pockets to get the funds for our agency.

Then our request for funds came before the Senate Appropriations Committee and again I was called to testify. I found that many Senators were interested in talking about how we were spending the taxpayers' money. Again I tried to tell them why we needed the money. The end result was that the Senate and the House finally got together and gave us a little over $700,000.

After the battle was all over, I was firmly convinced that it is not so easy to get money in Washington as a lot of people seem to think.

Even when budgets are up in the billions, I found that Congress still takes time to inquire into a mere dribble of $1,000,000.

There are plenty of people who want the government hydroelectric dams, the flood control projects, the reclamation service, the harbor improvements, and a thousand other services that the government can provide. More and more people look to Washington to solve their problems.

It is so easy when you are in Washington doing a job which seems to you to be very constructive, to forget about the blood and the sweat and the tears that go into earning the money to pay the taxes that pay for the job that you are doing.

I call your attention to the desirability of having men from industry, on loan from their companies on a "without compensation" basis, to administer some of these temporary controls. People serving on that basis are anxious to get back to their own companies and are not interested in perpetuating the controls. Industry will be wise if they keep sending people to Washington on that basis; otherwise, they may find a lot of defense controls becoming permanent controls.

Government in this country has grown tremendously. The Department of the Interior is the seventh largest government department. I used to think that the Consolidated Edison Company was a pretty big organization. We have in that company about 25,000 employees. As I recall, the biggest construction budget we ever had for any year in our company was about $100,000,000. Last year, the Department of the Interior, with its more than 60,000 employees, spent about $600,000,000. In this department are the great federal power operations of the Bureau of Reclamation, Bonneville Power Administration, Southwestern and Southeastern Power Administrations, and such widely diversified activities as the Bureau of Mines, Geological Survey, Fish and Wildlife, National Parks, Indian Affairs, and the Administration of Alaska, Hawaii, and Puerto Rico.

Top government administrators lead quite a different life from that of an executive in private business. Compared to a Washington administrator, the average businessman leads a sheltered existence. In Washington, your actions are subject to continual public review. A Congressional Committee may want to ask you questions. Your correspondence is usually open for inspection, except on classified information. You become accustomed to dealing with the press and issuing press releases.

You must expect, and you get, much more criticism than in business. That is because the tough decisions you have to make are seldom, if ever, popular with all of the people concerned.

You might assume that with the profit motive missing in its usual financial sense, life would be soft indeed. My observation is that in the top level jobs the administrative responsibilities are very heavy, and I can tell you from my own experience that while you may not need to be brilliant to hold down a top spot, you do have to have guts if you want to do your job right.

### THE PERSONNEL IN GOVERNMENT

I ALSO HAVE HAD a chance to observe the general run of government employees. It is my judgment that, with very few exceptions, they are capable and energetic.

The question of salary is always interesting. My secretary, who is a very efficient woman, gets about $5,000 a year. A Cabinet officer, like Secretary Chapman, gets $22,500 a year. On the other hand, I know some top administrators in the Department of the Interior who may be responsible for anywhere from 3,000 to 15,000 people, whose salaries range from $12,000 to $15,000 a year.

The government is constantly losing many of its top people because salaries have not kept pace with those of industry. The last figures that I looked at showed that 2,500 employees on the Civil Service rolls received $10,000 a year and up. Senator Paul Douglas of Illinois points out that salaries for the 2,500 could be doubled at an expense of only $28,000,000 a year, and the Federal Government would benefit many times over in better management.

In times like these, when jobs are plentiful, turnover in government employees is really tremendous. In the last fiscal year, over 300,000 federal employees quit their jobs. Just so you may know that people can be fired who work for the government, a little over 17,000 were discharged, and another 17,000 were removed from the payroll because projects on which they were working were completed.

The total number of civilians on the federal payroll is now nearly 2,500,000. About half of these people are employees of the Department of Defense, which, as you know, is the Army, Navy, and Air Force. The fact that half of the employees are in the military phases of government, emphasizes a point which all of us need to recognize and that is the tremendous amount of the federal govern-

ment expenditures that relate to past, present, and future wars. In the 1952 budget, only 17 per cent of the total government expenditures will go for the operation of the regular government agencies; 83 per cent will go for past, present, and future wars. You can see how expensive it is not to be able to solve the problem of peace in the world.

Of course, a big chunk of those expenditures now goes for the mobilization program which got under way when the Korean War started and which apparently will affect the lives of all of us for some time to come.

The President of the United States recognized that he would need a man to take charge of mobilization who understood American business. He selected a man whose life had been spent in production and top management, Charles E. Wilson. It was also clearly recognized that since American industry was going to have to produce under a system of controls, it was necessary that the people in charge of those controls have industry experience so that they could deal with the situation on a realistic basis. As a result, hundreds of engineers and executives have been working in Washington over the past year on loan from their companies.

In the Defense Electric Power Administration, practically all of our people, other than clerical, are engineers, and they are engineers who are familiar with the electric power business. When electrical utility people come to Washington to see us, they can talk with men who understand their problems. The result is confidence and co-operation.

However, I do not mean to imply that the engineers and production people have had a free hand to move ahead without the normal roadblocks that life always seems to offer. Decisions on major policy matters in the defense effort oftentimes reflect staff work done by economists and lawyers. To the lawyers and the economists, I must add the career administrative people who get in on policy decisions affecting businesses in which they have had no practical experience. After discussions with them, I have often returned to my office completely frustrated and out of patience with the human race. However, I finally hit upon a scheme which seems to be working for me. I got my own lawyers and my own economists, and after I indoctrinated them, I let them work out on their fellow professionals. One of my happiest moments in Washington was listening to my economist tell another economist who was interfering with the power program that his facts were inaccurate, his logic faulty, and his conclusions nonsense.

## THE POLICY MAKERS

We also found out that, in government as elsewhere, your engineering may be absolutely correct, but the fellow making the top decisions may still need just a bit of selling to help him understand. In our case, if the man making the decisions on materials for electric power thinks it is just like making automobiles or refrigerators, he will not be able to understand what we mean when we talk about long lead time. To solve this problem I got the General Electric Company, Westinghouse Electric Corporation, and the Babcock and Wilcox Company to produce some very fine booklets with no engineering, just pictures, like *Life* magazine, showing what actually went on in the shops where they made such things as turbogenerators, transformers, and boilers. Then I was able to get similar booklets showing how a steam power plant, a hydroelectric plant, and a big transmission line were constructed. When you do it with pictures and make it easy to get the idea, it is pretty effective. I sent these booklets to the top officials of the various mobilization agencies and, as a result, there are some people in Washington, important to us, who now understood why it takes from $2^1/_2$ to 3 years to build a steam power plant; why it takes up to 5 years to build a hydroelectric plant; why it takes 64 weeks to build a steam turbine; and why, when you start on one of these big programs, you cannot turn on a dime.

Of course this whole battle in Washington grows out of the fact that when you get into a big mobilization program, you have more demand for such things as steel, copper, and aluminum, than you have materials. So the government agencies have to decide who gets what and how much and when.

A year ago, at this time, the top policy makers decided that the power program was too big. Electric power was expanding 40 per cent in 3 years while industrial production was only expected to expand 20 per cent. One of the top mobilizers pointed to this 40-20 comparison as obvious proof that the power program was too big, and his minions followed through by giving us less material than we needed. I called upon my battery of economists and we confronted this gentleman and his economists with a little history of the electric power consumption in this country which had increased 3.6 times as fast as the national output and, hence, showed that a 40 per cent increase in power requirement for a 20 per cent increase in industrial production was far from being illogical.

Of course, the next thing that happened was the appointment of a committee to investigate the power program. Fortunately, this committee was made up of seasoned veterans who, after thorough study, reported that the power program was not too big, but was probably too small. As a result, today we have an approved 3-year program goal of 32,000,000 kw as compared to the expansion goal of 27,000,000 kw we were trying to sell only a year ago. It is pleasant to hear the economists all chanting the new party line which is that there is no substitute for electric power. All of the material allocators are now scrambling to make sure that we get everything we need. We are from 6 to 9 months late in arriving at our present position, because we had to deal with individuals who did not understand, rather than with engineers who did. Nevertheless, we have come a long way from this time a year ago, when one of the top mobilizers said if you do not have enough electric power in this country, let the people burn candles.

I never cease to marvel at the power that is placed in the hands of government administrators. At home, I make decisions that may involve the activities of some hundreds of people, and thus, in some small degree, influence affairs in New York City. The Congress, however, gave the

President of the United States vast powers under the Defense Production Act. The exercise of these powers in the electric power field comes by way of the Secretary of the Interior to me as Administrator. We decide which electric power expansion projects will be approved and which will be denied. We issue directives in cases of emergency saying who will get electric power and who will not. If someone in Hawaii, Texas, or New York wants help in getting some switchgear, a transformer, or a capacitor, he gives us all the facts and we decide whether we will help him or not. If an electrical utility wants a fast write-off on an investment, their project comes to us and we recommend whether they should be given tax amortization and how much.

In the exercise of these powers, an Administrator is subject to numerous pressures. It may be the high pressure of a Washington-wise gentleman who gets it across to you very early in the conversation that if you do not watch your step, he will have Congress breathing down your neck in no time at all. Or it may be a highly organized pressure group that tells you in no uncertain terms that while your decision may be fair, they have the political ability to have you overruled, and perhaps they can make it stick. Then, of course, you have friends and acquaintances who expect you to remember them. You also have the other government agencies in the power business who are firmly convinced that because the Congress has given them the money for power projects, they should come first.

The electric power industry is now about 80 per cent privately owned and 20 per cent publicly owned. There are about 5,000 power suppliers in the country including the rural co-operatives. You may have heard that relationships between the private companies, the Rural Electrification Administration, the federal power people, and the municipals are not always pink tea affairs. After about a year's experience, however, I have concluded that the percentage of so and so's in our industry is no higher than it is in any other business. In my more charitable moments, I sometimes think we have fewer of them; but then, someone comes in the next day and changes my mind.

The power of government makes a big impression on me. I keep thinking how easy it is for the people to give away the power, and yet how hard it may be to get it back.

The current steel situation where you have big government, big business, and big labor all in a tangle, illustrates the modern economic setup in America. Government is constantly playing a more important part in our affairs. It is obvious to anyone who has been a government administrator, that if we are to have a good government in this country, we must have the right people in the government jobs. That means we must have citizens in this country who are taking an interest in their government and trying to make it better. I doubt that we engineers have done as much as we can do to help good government. If patriotic reasons are not enough, I call your attention to the fact that budget expenditures of the Federal Government this fiscal year will take a little over 25 per cent of the national income. When somebody starts spending 25 per cent of what you make, the time certainly has come to take an active part in seeing that your money is spent wisely.

I believe that is one reward given to the engineers who have come to Washington to participate in the defense agencies. They have seen how government works. They have learned to appreciate its value and also to understand its power. They will, I hope, be more alert to their responsibilities as citizens.

Tftentimes, speakers in addressing groups about the Federal Government end up by making only one suggestion, and that is to write your Congressmen. We, in the Defense Electric Power Administration, have been on the receiving end of many letters to Congressmen, and I assure you that Congressional offices usually follow through on the letters. We always answer the letters sent to us. However, in about 95 per cent of the cases, the whole procedure becomes very routine. If you can get your Congressman personally interested in the subject, he can become a fairly effective pleader. My experience has been that most Congressmen are very fair to deal with, and while they ask a lot of questions, they do not try to interfere with the operations of our agency.

### THE ENGINEER'S FUNCTION

Occasionally I get quite a laugh out of some of the newspaper stories concerning our agency, particularly if they creep in to some of the high-powered columns. I am more firmly convinced than ever that you can believe only about half of what you read, and it is difficult to tell which half is correct. We have had excellent coverage in the trade press and that has helped in getting our story over to the power industry.

I have done some speculating on the philosophical side as a result of one of the problems which has confronted us in trying to solve an electric power shortage situation. Out in the Pacific Northwest, new hydroelectric developments are absolutely necessary because electric power has been short. The salmon use the rivers out there and they support a great many people in the fishing industry. The fishing industry is violently opposed to the construction of several dams which we have recommended. Their opposition is based on their belief that these dams will kill off a substantial amount of salmon and will throw people out of work and adversely affect the economy of the region. The Federal Power Commission has licensed these dams but the opponents have taken the dispute to the Courts.

This is one of those situations that we often philosophize about as to whether engineers recognize the social and economic implications that result from engineering progress. My personal opinion is that engineers are no different from other professional groups. The engineer must, I believe, follow the paths of progress regardless of the problems created by his achievements. The doctors, for example, have been able to increase the life span of people in this country to a point where old-age benefits have become a major social problem. I am sure this does not deter the doctors from trying to be of as much help as possible to humanity, and I doubt that any citizen would be against increased longevity because it raises some social and economic problems.

Just in case you do get into a discussion concerning engineers and social progress, I have a good example where engineering is definitely being used to promote social progress. The Department of the Interior has played a major part in the Point Four program. Point Four is the program for technical co-operation with peoples of the undeveloped areas of the world. The idea is to help the people in these undeveloped sections create a better life for themselves by showing them how to conserve and develop their God-given resources. Apparently we are trying to show the people in the less progressive nations how to raise more food to support the increasing population which is partly the result of longer life spans made possible by better sanitation and medical service. Wars, pestilence, and famine used to solve the problem of overpopulation. Who would want to turn the clock back?

The curricula of our engineering colleges are giving greater and greater recognition to the social and economic problems encountered by the engineer. We have been meeting a few of these problems in Washington, and the decisions more often are political than they are either engineering, economic, or social. Oftentimes it is hard to put in college textbooks just how and why things were done the way they were.

I look forward with a great deal of pleasure to my return to civilian life. I doubt that I shall ever again be the same person. If there is nothing else that I take with me from Washington, it will be the distinctive language of that famous city. In Washington, we never refer to our department. We talk about our shop. When they appoint a committee to deal with a specific problem, they refer to the assignment as an "ad hoc" detail. You do not refer to a difference between the objective and the accomplishment. You talk about slippage. You do not postpone or slow up a program. You phase it out.

I shall never again be able to think of electric power in terms of the Hudson River on one side and the Atlantic Ocean on the other.

I shall never again be able to deal in any normal way with a customer who wants just a few thousand kilowatts. Not when the Atomic Energy Commission comes in talking about adding 1,800,000 kw in one slug; or we sit down around a table and talk about interconnecting power systems involving millions of kilowatts.

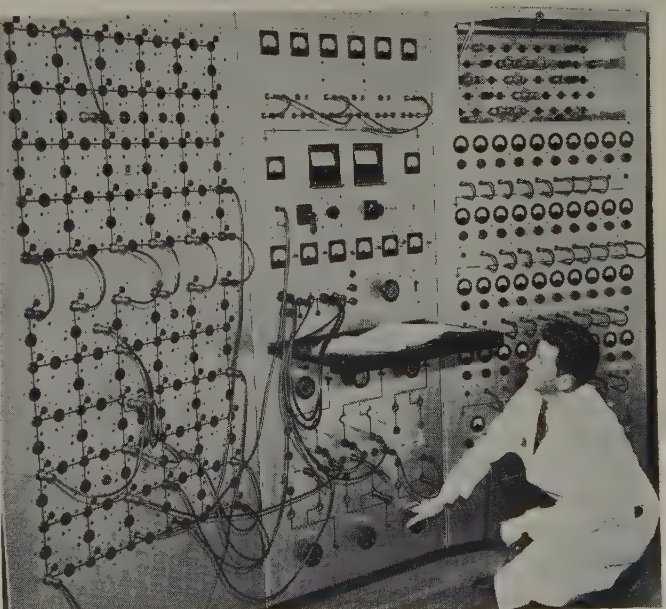
In fact, my bosses in New York have already worried whether they will ever be able to get me back to normal, after the exciting life in Washington, and my issuing directives hither and yon and exercising control over a great industry.

To the students, I recommend that in planning your career, you recognize that big government will play a much greater part in your lives than it did in the lives of your parents. When they were born, the Federal Government took $2^1/_2$ per cent of the national income. Today it is 25 per cent. As a result, your responsibilities for good government are many times greater than ever before.

To the professional engineers, I suggest that if the opportunity comes to you to get a bit of government experience in Washington, you accept your tour of duty because I am sure you will benefit from it.

Every engineer can contribute in some way to the success of the mobilization program. I urge that you give it your full support because, for the first time in our history, we are trying to prepare before a big war, rather than after it starts. Perhaps by this system, we may be strong enough to avoid the war.

## Flow and Pressure Drop Problems Solved in Pipe-Line Network Analyzer



**Solution of problems in pipe-line network installation and operation is facilitated through use of this McIlroy Pipeline Analyzer by engineers at Midwest Research Institute, Kansas City, Mo. The analyzer employs a unique arrangement whereby electric current simulates actual pipe-line flow. The left-hand panel of the analyzer is designed to represent a large variety of network layouts, comprising as many as 104 pipe lines. Special bulbs, called Fluistors, are installed on the reverse side of this panel and the brightness of tungsten filaments inside the bulbs indicates which pipe lines are operating with the largest pressure losses. These Fluistors give quantitative values of flow and pressure drops and are constructed to represent a wide range of pipe-line lengths, diameters, and roughnesses. Master instruments in the center panel indicate directly in fluid units the flow rate in any pipe line and the pressure drop from friction between any pair of pipe-line junctions. Flow rates to loads may be maintained either automatically or semiautomatically depending upon the equipment and the problem. This panel carries the controls which duplicate sources of supply, such as pumping stations and reservoirs. As many as six sources may be represented simultaneously. The right-hand panel contains equipment to simulate 43 loads which may have any desired flow rates, and may be connected to any terminals which represent pipe-line junctions**

# Progress Toward Unity of the Engineering Profession

FOR SOME YEARS NOW, engineers have been considering and discussing the problem of increasing the unity of the engineering profession. Many engineers have been critical of the fact that, while the existing technical societies serve them well, there is no organization which can represent adequately the entire engineering profession in the matters which are common to the entire profession. This need is filled, in part, by the effective co-operation of engineering societies through a number of joint organizations but the representation in these organizations and the scope of their activities is limited. From time to time various plans have been proposed for some type of over-all engineering organization which would go further than these present co-operative activities in expressing the unity of the profession. The various points of view of different groups of engineers regarding the means to achieve increased unity constitute one of the reasons why no conclusive action has been taken.

**To bring the reader as up to date as possible, and to clarify the objectives of the unity organization proposed by the Exploratory Group to Consider the Increased Unity of the Engineering Profession, the full text of the Group's report is presented herein, together with Secretary Osborne's letter of transmittal. Also included are the minority report submitted by the representative of the Exploratory Group from the NSPE, and those sections of the present EJC constitution which would be affected under such a plan.**

## FORMATION OF AN EXPLORATORY GROUP

ONE OF THE LEADERS in the unity movement in recent years was the late AIEE past president, Blake D. Hull, who vigorously advocated the holding of a constitutional convention for the purpose of devising some form of national organization such as the "American Engineering Association" proposed by the Professional Activities Subcommittee of the AIEE Committee on Planning and Co-ordination in 1947 (*EE, May '47, pp 496–501; Apr '48, pp 313–17*). Mr. Hull's efforts were continued by AIEE Past-President James F. Fairman (*EE, Aug '49, p 693*) who discussed the matter on his visits to the Sections. The results of a poll of opinion in AIEE Sections were presented in the March 1950 issue of *Electrical Engineering* (*pp 191–4*). At that time, a further poll of individual membership opinion was taken and the results of the poll were reported in *Electrical Engineering* (*Aug '50, p 669*).

In October 1949, at the invitation of the Engineers Joint Council, representatives of 16 major engineering societies formed the "Exploratory Group to Consider the Increased Unity of the Engineering Profession" with H. S. Osborne as Secretary.

The Exploratory Group adopted, as a basis for discussion by the societies, a progress report in which four different plans of organization were described. These plans, briefly, proposed the following:

Plan *A*—the expansion of Engineers Joint Council (EJC) to include other engineering societies.

Plan *B*—expansion of EJC to include other engineering societies and also to provide for a voluntary individual membership.

Plan *C*—the merger of EJC and the National Society of Professional Engineers (NSPE), modified so that the resulting organization would represent the entire engineering profession.

Plan *D*—adoption of NSPE as the unity organization and expansion of its membership and activities through the co-operation of other engineering societies.

## ACTIONS BY THE SOCIETIES

IN DECEMBER 1951, the Exploratory Group completed a report for submission to EJC and recommended as the most practicable approach that a unity organization be organized first by the development of EJC along the general lines of Plan *A*, this step to be followed at once by the consideration of other important steps outlined in the report.

On January 25 of this year, the EJC voted to receive the report of the Exploratory Group and refer it simultaneously to the Executive Committee and to the constituent societies of EJC for study and report back to EJC. Of the five constituent societies, the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the American Institute of Chemical Engineers approved the report in principle and requested the EJC to take the necessary steps to amend its constitution as recommended in the report. The Board of Directors of the American Institute of Mining and Metallurgical Engineers voted to receive the report, but have not taken any action one way or the other.

In the AIEE, the majority of opinion is in favor of an organization based upon individual membership. Plan *A* has been criticized as being based, instead, upon unity of engineering societies, and so it was voted that the plan not be accepted and that T. G. LeClair, AIEE representative on the Exploratory Group, continue his efforts toward bringing about the formation of a satisfactory unity organization.

SECRETARY OSBORNE'S LETTER OF TRANSMITTAL

*To Engineers Joint Council and to All Constituent Societies of the Exploratory Group:*

At a meeting on December 15, 1951, in New York, N. Y., of the Exploratory Group to Consider the Increased Unity of the Engineering Profession, the following resolutions were passed:

1. That the attached report be approved as the most feasible proposal for inaugurating greater unity of the profession which the Exploratory Group has been able to devise after months of consideration.

Mr. Van Praag dissented, all others voted in the affirmative.

2. That the report be transmitted to Engineers Joint Council (EJC) and to the constituent societies of the Exploratory Group.

Mr. Van Praag dissented, all others voted in the affirmative.

3. That EJC and the constituent societies of the Exploratory Group be requested to inform the Secretary of the Exploratory Group of the actions which they take on these recommendations, and the Secretary be directed to report these actions to all members of the Exploratory Group.

4. That the Exploratory Group expresses to EJC its appreciation of their statesmanship in inviting the constituent societies to form the Exploratory Group and meet under its auspices, and its thanks to the American Society of Civil Engineers, and other engineering societies for providing meeting rooms and secretarial assistance.

At this meeting, 13 of the 15 constituent societies of the Exploratory Group were represented, 12 by their regular representatives and one by an alternate. The societies not represented, were as follows:

American Society of Refrigerating Engineers

Institute of Aeronautical Sciences

In accordance with the instructions of the Group, I have the honor to transmit to you herewith their report.

Mr. Van Praag, who dissented from the approval of the report of the Group, has presented a minority report dated January 10, 1952. A copy of his report is also transmitted herewith.

In accordance with Resolution 3, I will appreciate it if you will advise me of the action taken on the recommendations contained in the report of the Exploratory Group and I will inform all members of the Group of these actions.

H. S. OSBORNE
*Secretary*

# Report of Exploratory Group to Consider the Increased Unity of the Engineering Profession, December 1951

### Section A—General Conclusions

*Introductory Historical Statement.* The "Exploratory Group" was formed by the invitation of Engineers Joint Council (EJC), sent under date of June 8, 1949, to 16 of the major engineering societies of the United States. Each society was invited to designate a representative to attend a meeting to explore the desirability and practicability of increasing the unity of the engineering profession.

The Exploratory Group first met October 20, 1949, and has met from time to time since. Also, there have been numerous meetings of its Planning Committee.

At a meeting on December 16, 1950, the Exploratory Group adopted for the purpose of discussion an extensive report prepared by the Planning Committee. This report included descriptions of four different plans for establishing a "unity organization."* Thirty-three hundred copies of this report have been distributed among the officers and other representatives of the 15 societies finally constituting the Exploratory Group. It has been the basis for wide discussion during the past 12 months of the various problems involved in bringing about increased unity of the engineering profession.

On September 28, 1951, the Exploratory Group received from its members oral reports of the results of these discussions. The reports indicated a very general agreement among engineers that immediate steps should be taken to achieve increased unity. As was to be expected, there were differences of view as to the best form of organization for this purpose. However, after full discussion a majority of the members present voted:

That a report be prepared including a recommendation from the Exploratory Group to its constituent societies and to EJC to the effect that a unity organization be organized first by the development of EJC along the general lines of Plan *A*, and suggesting further steps to be studied by the unity organization after the completion of the first step.

It was further voted that Mr. Osborne be requested to draft the proposed report, to be circulated to the members of the Exploratory Group for comment, and then to be submitted for action at a subsequent meeting of the Exploratory Group.

At its meeting on December 15, 1951, the Exploratory Group adopted this report as its recommendation to its constituent societies and to Engineers Joint Council. It does this with a conviction that the steps here proposed will be supported by a large majority of members of the

* Throughout this report the term "unity organization" is used for convenience but with no intention of suggesting this as a name for any organization which might result from this activity.

engineering profession and that they will lead toward an increased unity which will be beneficial to the profession and to the community at large.

*General Conclusions.* The general conclusions of the Exploratory Group are as follows:

1. It is desirable that the engineering profession establish a "unity organization" which will be able to advance the unity of the profession and the service of the profession to the nation.
2. The unity organization should be formed by the modification and development of a present organization or by the integration of two or more present organizations rather than by the establishment of an entirely new organization.
3. The unity organization should initially include the participation of a majority of the national engineering societies represented in the Exploratory Group.
4. There are a number of important questions regarding the form and activities of the unity organization and its relation to other engineering bodies on which there are differences of opinion within the profession. Accordingly, it is desirable that the unity organization be launched in the simplest possible way and that these questions be studied and determined by the unity organization itself rather than by the Exploratory Group or any other temporary group.
5. To bring about this first simple step the Exploratory Group recommends to Engineers Joint Council that it invite all constituent societies represented in the Exploratory Group to become constituent societies of the Council.
6. The Exploratory Group recommends further that, coincident with this invitation, Engineers Joint Council modify Article II—"Membership" of its Constitution in such a way as to provide for membership on the Council by representatives of the constituent societies appointed or elected for the purpose, and to provide for a number of representatives from each society, ranging from one to three. This recommendation is developed in more detail in Section *B* of this report.
7. The Exploratory Group recommends to the constituent societies of the Group that they accept the invitation of EJC and become constituent societies of that body.
8. Following these first steps, the Exploratory Group recommends that the enlarged Engineers Joint Council give further study to the matters discussed in Sections *C*, *D*, and *E* of this report and take appropriate action on each of these matters.

## Section B—Initial Changes in Provision Regarding Membership in the Constitution of Engineers Joint Council

It is recommended that coincident with the invitation to the engineering societies represented in the Exploratory Group to join Engineers Joint Council, the constitutional provision regarding the members of the Council be so modified that such members shall be representatives of the constituent societies elected or appointed for the purpose and shall vary in number from one to three in each society depending upon size. This can be brought about by changing Article II, Section 1*a*, of the Constitution to read as follows:

The Council shall comprise representatives elected or appointed by the constituent societies. Each society shall designate one representative for each 10,000 members (or fraction thereof) qualified to vote for national officers, with the qualification that no society shall have more than three representatives.

In accordance with this provision, the Council would have the following numbers of representatives if all associations represented in the Exploratory Group become members of EJC.

| Organization | Voting* Members | Number of Representatives on EJC Council |
|---|---|---|
| American Association of Engineers | 6,078 | 1 |
| American Institute of Chemical Engineers | 4,031 | 1 |
| American Institute of Electrical Engineers | 41,893 | 3 |
| American Institute of Mining and Metallurgical Engineers | 17,234 | 2 |
| The American Society for Engineering Education | 7,500 | 1 |
| American Society of Civil Engineers | 32,901 | 3 |
| American Society of Heating and Ventilating Engineers | 5,858 | 1 |
| The American Society of Mechanical Engineers | 37,000 | 3 |
| American Society of Refrigerating Engineers | 4,720 (9/1/51) | 1 |
| American Water Works Association | 8,400 | 1 |
| Illuminating Engineering Society | 7,166 | 1 |
| Institute of Aeronautical Sciences | 4,379 | 1 |
| Institute of Radio Engineers | 8,231 (9/1/51) | 1 |
| National Society of Professional Engineers | 24,213 | 3 |
| The Society of Naval Architects and Marine Engineers | 5,420 | 1 |
| Total | | 24 |

* As of October 1, 1951, except where otherwise indicated.

## Section C—General Objectives

*Objectives.* The objectives of Engineers Joint Council are well stated in Article II, Section 2, of the Constitution. The Exploratory Group suggests consideration of adding to this statement of purposes. To assist in this, the Group offers the following illustrative objectives which have been formulated in connection with its consideration of the matter. The first three of these are substantially those which now appear in the Constitution of EJC.

(*a*). To advance the general welfare of mankind through the technical knowledge and creative ability of the engineering profession.
(*b*). To promote co-operation among the various branches and groups of the engineering profession.
(*c*). To develop sound policies respecting public affairs in which engineering is an important factor.
(*d*). To stimulate engineers to take their proper place—individually and collectively—in public affairs.
(*e*). To enhance the recognition of engineering as a profession.
(*f*). To maintain high professional standards among engineers.
(*g*). To advance standards of engineering education.
(*h*). To further the professional progress of young engineers.
(*i*). To assist its affiliated societies to aid and encourage the advancement of the theory and practice of engineering.

*Scope of Activities.* The scope of activities of the unity

organization will, of course, at all times be determined by the desires of its members. It is recommended that the constituent societies recognize the unity organization as the major organ for co-operative work between them. However, this does not require the constituent societies to give up any of their present activities or their co-operation through other channels except as and when they find this to be desirable.

Within its field of activity the unity organization should deal directly with government agencies and with others as a representative of the engineering profession.

The unity organization should have its own staff, in order to fulfill successfully the responsibilities which the constituent societies will wish to entrust to it.

Without in any way suggesting the initial scope of activities, the Exploratory Group submits for information the following specific purposes developed in its discussions, which it suggests should come up for consideration from time to time in the unity organization, and in determining its relation to Engineers' Council for Professional Development and other co-operative activities.

(*a*). To foster the relations of the engineering profession with other professions and with the sciences.

(*b*). To guide the co-operative activities, within its scope, among the various national engineering societies.

(*c*). To correlate the activities, within its scope, of regional, state, and local engineering and quasi-engineering organizations.

(*d*). To assist in co-ordinating student chapters of engineering societies.

(*e*). To assist governmental units in matters referred by these units to the engineering profession.

(*f*). To express the views of the engineering profession on public questions with an engineering aspect.

(*g*). To analyze and express opinion on proposed or pending legislation on which the engineering viewpoint can be of value.

(*h*). To formulate criteria for colleges of engineering and to help in other ways to develop the educational and vocational orientation of young men wishing to become engineers.

(*i*). To study the economic status and employment of engineers.

(*j*). To increase public recognition of the achievements of engineering.

## Section D—Major Questions to Be Considered by a Unity Organization

The Exploratory Group regards the following matters of paramount importance for determination if a unity organization is to be established on an adequate basis and to function successfully. Therefore, it is recommended that in the invitation of EJC to additional societies to affiliate with the Council, it be indicated that the following matters will be placed before the expanded EJC for prompt consideration.

*Membership—National Engineering Societies.* Since the unity organization is intended to represent all engineers, it is desirable that the constitution include a statement of the standards to be met by a national engineering society to make it eligible for consideration for membership.

Requirements for membership are now stated in Article II, Section 3, of the EJC Constitution. It is recommended, however, that consideration be given to revising this so that the qualification would depend upon:

1. The professional qualifications as engineers of the members of the society.
2. Minimum size of membership as a qualification for voting membership in the unity organization.

*Membership—Regional Societies and Councils.* The Exploratory Group believes that affiliation with the unity organization of regional, state, and local engineers' societies and councils is important for the organization fully to carry out its responsibilities as a general representative of the engineering profession. This subject is very complicated because of the interrelationship of the local and regional societies and their relation to the national engineering societies and because of the existence in some areas of competing regional groups.

It is hoped that the integration of co-operative effort at the national level evidenced by the development of the unity organization will enable that organization to establish increased unity and order in the relationships between regional, state, and local groups. It is recommended that the unity organization work upon this problem with sustained vigor, patience, and understanding.

*Membership—Individuals.* The Exploratory Group believes that provision in the unity organization for some form of membership of individuals is an important and perhaps necessary element of strength. This point of view is expressed also in some of the reports of the views of the constituent societies. On the other hand, there is no unanimity of view as to the nature of and qualifications for such membership.

It is recommended that this matter be given serious study by the unity organization. Section *E* of this report presents a discussion of the principal factors bearing on this matter as they have come before the Exploratory Group.

*Financing.* The expenses of the unity organization will depend upon the scope of its activities which in turn will determine the necessary size of its staff. Assurance of the maintenance of an income adequate to support the program of activities decided upon at any time is naturally a fundamental necessity. The means of doing this will depend in part upon the decisions made regarding membership, particularly whether or not dues-paying individual members are to be included as a part of the organization. The Exploratory Group believes that the contributions which the constituent societies may make to the cost of operation of the unity organization should be in proportion to the numbers of members of these societies qualified to vote.

*Relationship to Engineers' Council for Professional Development.* The scope of activities will be influenced by a determination of the relationship which should exist between the unity organization and Engineers' Council for Professional

Development (ECPD). There should be no duplication of effort or activity. It is the view of the Exploratory Group that the interests of the profession would be advanced by the integration of ECPD as a department of the unity organization. Properly carried out, it should be possible to bring about such an integration without losing the impetus which ECPD now has as an active and effective organization.

*Relationship to National Society of Professional Engineers.* The initial step of the unity organization here proposed places the National Society of Professional Engineers (NSPE) on the same footing as the other societies represented in the Exploratory Group, namely, as a prospective member of EJC.

However, one of the plans studied by the Exploratory Group and included in their report of December 16, 1950, contemplates a type of organization in which NSPE, with appropriate modifications, would be merged with EJC to form the unity organization.

It is recommended that careful study be given to the relationship between the activities of NSPE and those of EJC as a whole with a view to working out the most harmonious and effective relationship.

*Name.* It has been suggested that the present name, "Engineers Joint Council," might be changed to advantage.

### Section E—Membership of Individuals in Unity Organization

In the discussions of the advantages and disadvantages of a provision for membership by individuals in the unity organization, three general bases for such membership have been considered:

*1. Automatic Membership.* All members of the constituent societies would be considered automatically to be members of the unity organization. In an alternative this might apply only to all members in certain selected grades of membership.

*2. Voluntary Membership—Broad Base.* All members of the constituent societies would be eligible to be candidates for membership in the unity organization, action by that organization being necessary for their election. Eligibility might be limited to certain grades of membership, for example, to all voting members of the constituent societies. As an alternative, members meeting the qualification for Junior membership in the Founder Societies (in AIEE the corresponding grade is Associate membership) or higher grades would be eligible. This would give a base of eligible members of approximately 200,000 (without correction for duplications).

*3. Voluntary Membership—High Professional Standards.* In this form of membership, members of the constituent societies in grades of membership requiring a high degree of professional competence and more than 5 or 10 years engineering experience would be eligible. This would correspond in general to the grade of Member in the Founder Societies. About 100,000 engineers would be eligible.

In the discussions of this matter in the Exploratory Group, it is agreed that whether or not there is a later provision for individual membership, the constituent societies should initially control the operations for the unity organization.

The advantages of provision for individual membership in the unity organization suggested by some members of the Exploratory Group include the following:

1. It would enlist maximum personal interest of the engineers in the activities of the unity organization.

2. Membership by individuals would provide a mark of professional recognition which should be a strong element in furthering the unity of the profession. This is particularly true with the type of membership indicated in foregoing paragraph 3 and progressively less with the types of membership of paragraph 2 and paragraph 1, respectively.

3. It provides a stable basis for the support of the unity organization without burdening the national engineering societies.

The disadvantages of provision for individual members which are suggested by some members of the Exploratory Group include the following:

1. The possibility that the individual members as such would demand a voice in the government of the unity organization and that this might, in the long run, tend toward a reduction in the control of the organization by the constituent societies.

2. The possibility that the greater facility of raising financial support, represented by the individual dues, may result in a larger program of activities of the unity organization than otherwise and that this may react to the disadvantage of the constituent societies.

The form of organization which would result from having complete control in the hands of the constituent organizations and major financial support coming from voluntary dues-paying individual members is not novel but has been used with success by others. An example of this form of organization is the American Association for the Advancement of Science which was formed more than 100 years ago. This association consists of 218 affiliated or associated scientific organizations (including several engineering societies) and about 45,000 individual members. Ninety per cent of the members of the governing body are elected or appointed by the affiliated societies. The financial support of the Association comes almost wholly from the individual members.

### Minority Report—by Alex Van Praag, Jr., Representative of National Society of Professional Engineers

*General Statement.* Any recommendation for a unity organization for the engineering profession should have the support of a large majority of the engineer members represented by the participating societies. This direct expression from engineer members of our profession has only been accomplished to date in a small area of the profession.

Discussion and co-operative efforts therefore should be continued to educate every professional engineer in this country in the details involved in a unity organization

before attempting a conclusion on the type of unity organization to be recommended.

The nonendorsement of even a single large group should be overcome before a unity organization is decided upon.

*Major Items Not Yet Resolved.* If and when a specific plan is proposed and recommended, that specific plan ought first to have resolved many of the important problems which are yet left quite vague or undetermined. The discussions of the Exploratory Group have not been concerned to date with solving all the problems which are recognized as problems of magnitude. Such procedure was entirely proper, but if a specific plan is to be recommended at this time, such specific plan must first have resolved important issues involving both principle and detail. There are a number of overlapping objectives and services between the proposed unity organization and several societies now represented in the Exploratory Group. Societies thus affected will be rightly concerned as to the effect the unity organization will have on their activities.

*Individual Membership.* The deliberations of the Exploratory Group over a period of more than 2 years have shown a majority of the members as preferring a unity organization based upon a democratic individual participation type of membership. This appears to be fundamental to a unity organization of a type that will long endure. The December 1950 report of the Exploratory Group clearly provided that:

> "Provisions should be made for the membership of individuals in the unity organization. Such members should pay individual dues to the unity organization."

This declaration was one of the agreed principles to be inherent in the unity organization. Adoption of the present proposed report does not provide for this previous determination and declaration of policy. The adoption of the present report then is quite inconsistent with the determination to provide for individual membership participation.

*Authority for Action.* The authority for action on the part of the unity organization must be clearly defined. Unless the unity organization is given authority to act on behalf of the engineering profession, with provision made for a binding decision to be reached by democratic processes, support for this decision not being optional with the participating societies, a unity organization cannot be successful or enduring. The unity organization must be given final and complete authority to act on behalf of the profession. There cannot be a system of participation or nonparticipation at the choice of each of the participating societies, either in support of the policies or the financing of the unity organization. If one or more major societies withdraws from the council, what happens to the organization or, more important, the unity in the profession?

*Organization Beyond National Level.* To be successful, the unity organization must be organized on a 3-level basis, or at least at other than the national level only. It is evident that the unity organization must have grass roots representation if it is to be effective. The problems of the profession are such that there must be co-ordination and liaison for all problems of the engineer which exist at state and local, as well as the national level. For example,

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**Societies Represented in and Members of the Exploratory Group**

American Association of Engineers: James H. Griffin, chief engineer, Board of Transportation of City of New York, New York, N. Y,

American Institute of Chemical Engineers: Dr. L. W. Bass, U. S. Industrial Chemicals, Inc., New York, N. Y.

American Institute of Electrical Engineers: T. G. LeClair, chief electrical engineer, Commonwealth Edison Company, 72 West Adams Street, Chicago 90, Ill.

American Institute of Mining and Metallurgical Engineers: James L. Head, Anaconda Copper Company, 25 Broadway, New York 4, N. Y.

American Society for Engineering Education: Dean Thorndike Saville, College of Engineering, New York University, New York 53, N. Y.

American Society of Civil Engineers: Carlton S. Proctor, 420 Lexington Avenue, New York, N. Y.

American Society of Heating and Ventilating Engineers: Dean L. E. Seeley, University of New Hampshire, Durham, N. H.

The American Society of Mechanical Engineers: Edgar J. Kates, 415 Lexington Avenue, New York 17, N. Y.

American Society of Refrigerating Engineers: Professor Burgess H. Jennings, Mechanical Engineering Department, Northwestern University, Evanston, Ill.

American Water Works Association: Harry E. Jordan, American Water Works Association, 521 Fifth Avenue, New York, 17, N. Y.

Illuminating Engineering Society: S. B. Williams, Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

Institute of Aeronautical Sciences: S. Paul Johnson, Director, Institute of Aeronautical Sciences, 2 East 64th Street, New York 21, N. Y.

Institute of Radio Engineers: Dr. B. E. Shackelford, RCA Building, Room 1242, 30 Rockefeller Plaza, New York 20, N. Y.

National Society of Professional Engineers: Alex Van Praag, Jr., Warren & Van Praag, Inc., 253 South Park Street, Decatur, Ill.

The Society of Naval Architects and Marine Engineers: J. H. King, Babcock and Wilcox, 85 Liberty Street, New York 6, N. Y.

R. E. Dougherty, Consulting Engineer, 101 Park Avenue, New York, N. Y., President, Engineers Joint Council, 1949

H. S. Osborne, *Secretary;* Chairman, EJC Committee on Unity of the Engineering Profession; Chief Engineer, American Telephone and Telegraph Company, 195 Broadway, New York 7, N. Y.

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legislation and government representation, agreed to be a principal interest of the unity organization, is affected by action at individual, local, state, and national levels.

*Financing.* The extent and manner of financing the national unity organization and its activities should be fully resolved before a specific plan is recommended. An intelligent vote on the adoption of a final plan demands an adequate prior determination of the principles and extent of the financing. Such is not provided in the proposed report.

*Conclusions.* With the foregoing expression of certain principles and policies which, in turn, have not been resolved to date in the deliberations of the Exploratory Group, many believe that recommendation for a unity organization at this time is immature.

Elements of the profession should be encouraged to publicize and discuss through all means available to their respective societies the need for and the objectives of a unity organization upon which there seems to be no difference of opinion.

The subject should be pursued until there is developed a plan which will be acceptable not only to the executive direction of the participating societies, but to a large majority of their individual members.

It is urged that no specific plan be fostered until first there shall be further discussions and education of the profession, and second a polled expression of opinion from members of the profession on which to base further implementation of the unity organization.

Thereafter, it would be appropriate, and only then, for the Exploratory Group to develop details for the unity organization and to recommend the adoption of a specific plan.

# Constitution of Engineers Joint Council

**The sections of the (EJC Constitution quoted in the following are those which would be affected by the plan under consideration.)**

### ARTICLE I—NAME AND OBJECTIVES

1. The name of this organization shall be Engineers Joint Council.

2. The objectives of the Council shall be:

(*a*). To advance the general welfare of mankind through the available resources and creative ability of the engineering profession.

(*b*). To promote co-operation among the various branches of the engineering profession.

(*c*). To develop sound public policies respecting national and international affairs wherein the engineering profession can be helpful through the services of the members of the engineering profession.

3. To achieve these objectives, the Council shall:

(*a*). Act as an advisory and co-ordinating agency to seek and study matters of mutual interest to the constituent societies of Council and to recommend parallel action by them.

(*b*). Represent the constituent societies of the Council in instances in which constituent societies deem such joint representation to be desirable.

(*c*). Administer on behalf of the engineering profession, those activities authorized by a majority of the constituent societies of the Council.

### ARTICLE II—MEMBERSHIP

1. (*a*). The Council shall comprise the two most recent available past presidents and the secretaries of the constituent societies of Council. Availability of past presidents shall be determined by the constituent society that they are to represent. Should any constituent society determine that its past presidents are not available for assignment to EJC, the governing body of such constituent society shall appoint a representative to serve as a member of EJC.

(*b*). The president of each constituent society shall be ex-officio a member of Council and shall be expected to attend all meetings with all privileges except that of voting unless serving as an official alternate.

(*c*). Each constituent society shall appoint an official alternate from the membership of its governing board, who shall act as a member of Council, with full privileges, when any member of Council, representing his constituent society, is absent from Council meetings; when not substituting for an absent member he shall have privileges without vote, and shall be expected to attend all meetings of Council.

(*d*). The representatives and alternates of constituent societies shall serve for the calendar year.

2. The constituent societies of the Council shall be:

The American Society of Civil Engineers
American Institute of Mining and Metallurgical Engineers
The American Society of Mechanical Engineers
American Institute of Electrical Engineers
American Institute of Chemical Engineers

3. A national engineering society may become a constituent society of the Council upon proof that the qualifications required of its members classify them as constituting a generally recognized branch or group of the engineering profession and upon not less than a two-thirds affirmative vote of such constituent societies of the Council. Any member society of EJC may resign from membership upon a 90-day written notice to the secretary of EJC.

### ARTICLE VI—AMENDMENTS

1. This Constitution may be amended by an affirmative vote of the governing boards of not less than two-thirds of the constituent societies.

# Capacitive Current Switching With Circuit Breakers

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ALTHOUGH POWER circuit breakers are designed primarily to interrupt heavy inductive short-circuit currents, system growth in recent years has produced a greatly increased requirement of interrupting relatively lighter currents associated with the switching of capacitive kilovolt-amperes. This capacitive kilovolt-ampere requirement has manifested itself in long-distance high-voltage transmission lines, in relatively long high-voltage cables, and in large-size shunt-capacitor banks which are becoming a common fundamental unit in system design and operation. There is not necessarily a relationship between the ability of a circuit breaker to interrupt short-circuit currents and its ability to switch capacitance currents. It is recognized widely that high-frequency voltage and current oscillations may be produced which, if uncontrolled, may result in damage to apparatus or system outages.

Generally speaking the problem is not one of failure of the circuit breaker to interrupt the current or to close the circuit but rather one of the severity of the system disturbances produced by the switching operation, either opening or closing.

Discussed in this article are the following: 1. typical circuit-breaker performance in switching capacitive kilovolt-amperes; 2. circuit behavior and circuit-breaker performance considerations from test laboratory and transient analyzer studies; 3. criteria of acceptable circuit-breaker performance in capacitive switching.

From field experience and from laboratory and analytical information, in the application of power circuit breakers for switching capacitive circuits, the following observations and conclusions were made:

1. Circuit breakers not designed with proper provision for the switching of capacitive circuits may produce random restriking under certain conditions resulting in transient voltages which may cause system outages or even damage to apparatus.

2. With certain circuit configurations, switching of capacitive currents can result in higher transient voltages at some remote location than those produced at the circuit-breaker location.

3. Although the presence of an energized capacitance at the switch location results in lower transient voltages than would be experienced if the energized capacitance were not present, the transient currents occurring on closing or restriking of the switch are increased greatly.

4. One of the methods of adapting circuit breakers for the successful interruption of capacitive currents is to employ a properly designed resistance shunting the main contacts during a portion of the opening and closing stroke. With this approach, transient voltages and currents obtained if restriking occurs can be limited to values no greater than those encountered on circuit closing.

5. Another effective means of controlling random restriking is to force the interrupting medium to flow between the circuit-breaker contacts by means of energy independent of the arc so that the number of restrikes will be limited or even eliminated.

6. Considering circuit breakers for the entire voltage range, restrike-free operation would be desirable for the interruption of capacitive kilovolt-amperes. Such circuit breakers can be designed and constructed. However, the economic factors up to the present time have been such that this ideal performance for all conditions has not been adopted generally in practice. Furthermore, the maximum possible transient voltage at the switched capacitance from one restrike, even though its magnitude is not limited by circuit-breaker design, usually will not impose any undue hardship on the system. Accordingly it would appear that criteria of acceptable circuit-breaker design and performance with regard to transient system voltages should be based on either limiting the number of restrikes to not more than one regardless of the voltage magnitude or limiting the magnitude of the transient voltages regardless of the number of restrikes.

7. In view of the foregoing considerations it is proposed that the maximum capacitive kilovolt-ampere switching capability of a circuit breaker shall be determined when switching cables, overhead lines, and shunt capacitors on effectively grounded systems under normal voltage conditions by the following:

(*a*). If, as the result of possible restrikes, the transient voltages to ground on fault-free circuit opening do not exceed two times the normal line-to-neutral crest voltage. Under the same conditions this is the maximum transient voltage that can be obtained on circuit closing; or

(*b*). If it can be demonstrated that the circuit breaker is so designed that under fault-free conditions not more than one restrike per phase may possibly occur on interruption; and

(*c*). If the circuit breaker is capable of successfully opening and closing the maximum transient currents associated with the maximum kilovolt-amperes as determined by either *a* or *b* provided these currents do not exceed the momentary rating of the circuit breaker.

In the foregoing criteria the term restrike is defined as a re-establishment of current one-quarter cycle or longer following interruption of a capacitive current at a normal current zero.

Digest of paper 52-39, "Switching Capacitive Kilovolt-Amperes With Power Circuit Breakers," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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# Long-Duration Surge Testing of Lightning Arresters

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A METHOD OF long-duration surge-withstand design testing of station-type lightning arresters is proposed for consideration by the industry. The test method involves successive applications of a surge having an essentially constant magnitude and a duration measured in thousands of microseconds.

The necessity for arrester surge-withstand design tests has long been recognized. Since 1944, the arrester standards have specified a 100-kiloampere 5x10-microsecond discharge-capacity test for station-type arresters. However, field measurements, field experience, and laboratory tests have all shown that the present type of surge-withstand test has very little significance in relation to the arrester's ability to withstand lower-current longer-duration discharges. Limited field data have established that multiple long-duration discharges through arresters occur both from lightning and from surges associated with switching transmission circuits. Accordingly, an additional surge-withstand test, such as that discussed in this article, is equally necessary for the low-current long-duration region of the discharge current scale.

It is proposed that the long-duration surge-withstand test for station-type arresters should consist of 20 successive applications of a surge having an essentially constant magnitude (less than 10 per cent decrement) maintained for at least 2,000 microseconds. Successive applications of the test surge should be made in five groups, each having four surges in rapid succession, with intervals between groups of not more than 15 minutes. The test might be performed on complete arrester units or on prorated characteristic elements rated 3 kv or greater.

Although experience by others in the industry undoubtedly will be necessary before standard values can be adopted, it is suggested that a test surge having a magnitude of 150 amperes and a duration of 2,000 microseconds be considered as representative of minimum requirements for station-type arresters, for thepresent.

Typical volt-time and ampere-time oscillograms of 1st and 20th applications of such a test surge to a 3-kv station-type lightning-arrester valve element, are seen in Figure 1.

The proposed type of long-duration test surge can be produced readily in the laboratory, using a distributed-constant impulse generator. By proper design of the test circuit, the severity of the test can be held constant between tests on different valve-element materials or between tests with different impulse-generator parameters.

Service experience over many years has been excellent with station-type arresters of a modern design, which has passed successfully both the suggested long-duration surge-withstand test and the high-current short-duration test required by the present standards. No failures of these arresters have been reported which were traceable to lack of discharge capacity. Occasional service failures from long-duration lightning or switching surges have been experienced with arresters of other than modern station-type design. Laboratory tests on these other designs indicated that they would easily pass the present standard high-current short-duration surge-withstand test, but would not pass the suggested low-current long-duration test for station-type arresters. Thus laboratory tests confirm service experience, and both indicate the need for such a long-duration surge-withstand test. They also substantiate the suggested minimum test values.

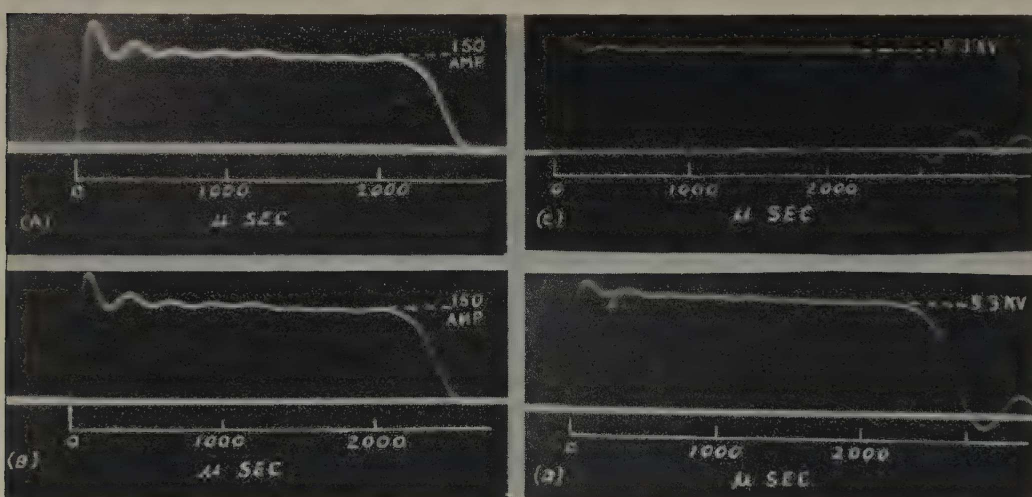


**Figure 1. Oscillograms of long-duration surge-withstand test applied to 3-kv station-type lightning-arrester valve element**

*A—Ampere-time, 1st discharge*
*B—Ampere-time, 20th discharge*
*C—Volt-time, 1st discharge*
*D—Volt-time, 20th discharge*

Digest of paper **51-278,** "Long-Duration Surge Testing of Lightning Arresters," recommended by the AIEE Protective Devices Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Published in AIEE *Transactions*, volume 70, part II, 1951, pages 1487–92.

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# Tomorrow's Engineer—In Preparation

K. B. McEACHRON, JR.
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**If we are to provide for a future adequate supply of engineers, we must go back to the secondary, and even the primary, school age groups to interest our young people in science and mathematics as a preparation for engineering training. In addition, there are still many ways in which we can improve technical education at the college level.**

WE HAVE ALL heard much, in the past 2 years, of the present and future shortage of engineers. Many professional and technical societies, including the AIEE, have been actively concerned with studying the problem, and have made specific recommendations to help alleviate this condition. There has been a rather general feeling that we must substantially increase the numbers of graduates to meet more nearly the present demand of industry, which is estimated variously from 30,000 a year up. Such activities are certainly desirable to counteract the previous opinion of the public—that engineering is an overcrowded profession. We in engineering, however, should know more of the problem—should know whether, in fact, we can produce as many graduates as industry requires.

Dean Hollister, president of the American Society for Engineering Education, has made an analysis of this problem which can be summarized briefly as follows. Based on the results of giving the Army General Classification Test to high-school seniors, we can expect a normal distribution of scores on this test to range principally between 40 and 160, with the maximum number of students receiving a score of 100. We have learned by experience that those persons who aspire to professional careers generally have classification scores of 125 or more. The per cent of high-school seniors with scores above 125 is about 10.6. We can, therefore, logically assume that 10.6 per cent (or 117,000) of the 1,100,000 persons who become of college age each year are qualified to enter one of the professions. In round numbers, there are 1,200,000 professional people in the United States, at the present time, divided roughly as follows:

400,000 in engineering
200,000 in medicine
200,000 in science
200,000 in education
200,000 in others

In view of the great demand for manpower in the professional areas other than engineering, it is unlikely that we can expect to attract to en6ineering more than our share of these people, as indicated by present distribution among the professions. Our share (33 per cent) of the 117,000 persons entering the professions a the freshman level is 39,000. While there is an impression in some quarters that the drop-outs in college are greater for engineering than for any other profession, the fact is that the mortality for all reasons among all professions is the same, and is roughly 50 per cent. We therefore, can expect to graduate from the 39,000 entering freshmen about 19,500 men.

While we might increase these final figures somewhat, by reducing the entrance and work standard requirements for college, we would increase the numbers very little unless there were such a substantial reduction in standards as to threaten seriously the effectiveness of engineering education as a whole. Dean Hollister concludes that we cannot hope to obtain satisfactory results by lowering standards, and that never again will we have an excess of engineering graduates. He has challenged the colleges to evaluate the effectiveness of engineering education at present, and to seek ways and means to improve substantially the educational process itself.

## BACKGROUND FOR INTEREST

BUT WHAT DOES all this mean to us in the engineering profession? First of all, it is clear that no longer can we expect to receive from the colleges the sheer quantity of engineering personnel, in relation to our needs, that we have in the past. Whenever industry has needed additional engineers, it has merely increased its demands upon the colleges, and, except for the war and postwar years, these demands have been met. We have been little concerned, until recently, either as a profession or as engineering educators, with the mortality problem during college or with the percentage of high-school students entering our engineering schools. When we examine our degree of professional interest in whether boys entering high school elect mathematics and science or general and vocational courses, it is no exaggeration to say that we have not even been conscious of the problem. That there is a job to be done at this point is indicated by the estimate of the Superintendent of Schools in Schenectady, N. Y., that fully 30 per cent of the boys who do not elect to take algebra in the ninth grade are fully prepared from an ability standpoint to do so, but do not because of lack of interest. In considering the preparation of tomorrow's engineer, it is clear that we must go back much further than we ever have before, and understand the problem much more completely.

We must first recognize the substantial shifts that have taken place in the last 2 decades in the way in which we live.

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Full text of a District paper presented at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. A companion paper, "Tomorrow's Engineer—In Use," by Guy Kleis, Westinghouse Electric Corporation, East Pittsburgh, Pa., appears in this issue (pages 603–05).

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More and more, we live together in towns and larger cities. The introduction of power equipment in farming has reduced the numbers of people required in this industry. The increasing mechanization and importance of manufactured products in our civilization has hastened the trend toward urban living and away from rural life. As more complicated manufactured products become commonplace in the urban home, there is an increasing acceptance of them for what they will do for us, with little concern of how they do it. Certainly few parents, for example, would think today of repairing a breakdown in their television set themselves. But in the 20's almost everyone who owned a Model T was, or became, an amateur mechanic to keep it in repair. In the home environment of today there is a very natural tendency for parents to be impatient with the curiosity of children, because in so many cases they themselves lack any understanding of the operation of the commonplace appliances. The shift in population from country to city has accelerated this change greatly. Repair and service facilities in cities are available today to a degree unknown only a few years ago. Even as late as 1937, when the General Electric Company organized its Creative Engineering Program, we found that a high percentage of engineers with an unusual degree of ingenuity had come from rural or farming areas. These boys had had experience in making things work, because they had no other choice. When a piece of equipment broke down, the most efficient way to fix it was to do it themselves. While today men with such background are still, in general, more creative, the percentage of men with such ability has been substantially reduced. Since the war, we have found it unusually difficult to discover as many men with creative ability, in proportion, as we did before the war. And this is at a time when the colleges have been graduating a very much larger number of men with appreciable experience, either military or industrial. The first and foremost problem thus is one which is a product of our present environment.

I believe, however, that we can do a great deal to substitute equally valuable experiences for those natural ones that have been lost. We can begin by making sure that our own children are encouraged to understand how things work. We should see that they are exposed to the experience of building a crystal radio set or a tin can motor. Too many times our tendency is to assume that children will pick these things up automatically with no guidance or encouragement from parents. Particularly in their younger years, children are very sensitive to the things which parents consider important. No greater encouragement can be given a youngster of 10 or 12, in developing an interest in how things work, than for his Dad to work with him in making or building simple devices of this character. On an organized basis, such activities as Cub Scouting and Junior Achievement provide ways whereby any interested adult can help in stimulating young people to develop their natural interests along these lines. In most cases, very little positive encouragement is needed. Curiosity is a natural characteristic of most young people. We merely need to guide it in productive directions, and thus to avoid suppressing it.

From a professional point of view, I believe we have taken little or no interest or responsibility in this initial phase of preparing engineers. As an organization, we have practically no contact with the home environment from which future engineers will come. While this has not been too serious a handicap in the past, as the trends I have described continue, professional societies must assume a responsibility in this area of which they are not now nor ever have been conscious.

## EARLY DEVELOPMENT

Concurrent with an interest in discovering how common things around the home and community work, all children develop skills, through formal education, in reading and writing. In each of these they can see immediate and valuable results. With only the slightest encouragement, a youngster will be eager to learn how to read to satisfy his natural curiosity of what is contained in books, newspapers, sign posts along the road, and so on. He is almost as much interested in learning how to write, because writing is such a familiar experience to all of those around him. Mathematics, however, is a much more abstract skill, and one about which he has much more natural reservation. Yet, here is the beginning of his formal education for engineering. The modern school attempts to help develop such motivation by emphasizing the use of addition, subtraction, and multiplication in such commonplace experiences as buying and selling. Still, for many years to come, arithmetic and mathematics represent to the average youngster abstractions which he would just as well do without. This attitude is one which appears in the common complaint of most grammar school pupils, that arithmetic is too hard and they do not like it. Add to this natural condition the prevailing attitude of too many of our people today—that any task that is really very difficult should be avoided if at all possible—and the surprising thing is that there is still in our public school systems as much emphasis upon mathematics as there is. It is under such adverse conditions that the entering high-school student is asked to elect whether he shall continue with mathematics (with the first course in algebra) or elect some other subject commonly regarded as a "snap." The activity of guidance counsellors in the public schools is often more concerned with progressing students through school than with actually developing for each individual a program of study which meets his needs and interests. Such guidance as the student receives, therefore, is more often negative with respect to mathematics than positive. Except for those few parents whose vocation lies in science or engineering, there is little appreciation in the average home of the effect of this early decision on limiting the opportunities open to the high-school graduate.

## SECONDARY EDUCATION

There is a strong and rapidly increasing conviction on the part of secondary school principals and administrators, that it is far more desirable for persons of high-school age to be in high school than out on the streets or in regular employment. Consequently, high schools today have a much higher proportion of students who are occupying space than who are really personally and seriously interested

in gaining an education. Another emphasis is that students must not be permitted to fail; rather they should be given such level of work that they will always, or almost always, succeed. Irrespective of whether these are correct psychological concepts their application to secondary education has substantially reduced the average academic level of the high school. As the percentage of those students in high school more for a place to be than to gain an education has increased, the high school has become more and more concerned with the education of this group of students than with the more able and interested. While the objective of keeping large numbers of students in school instead of turning them loose may be desirable in the public interest, it is certainly not in such interest that this objective reduce or retard what otherwise would be the progress of the interested and able students. Lord Rutherford, in discussing education in England and the United States, has said, "I grant that the average of your graduates is higher than ours, but you can't touch our top men. We don't pay much attention to the average man, he may get something from the atmosphere, but we devote ourselves to the top quarter of the class." In our preoccupation with the mass of students in high school today, we, as a profession, and high-school principals and administrators in general, have neglected to encourage sufficiently those who are capable and who could be interested in mathematics and science.

We too frequently have assumed that the problem lies only in encouraging the high-school senior to enter an engineering college. The real problem is to make sure that by the time he becomes a high-school senior he has had the necessary mathematics and science to qualify him for entrance to an engineering college.

Last fall in Schenectady, we arranged for some of our most qualified young engineers to discuss with high-school students beginning algebra in the public schools the importance of continuing and increasing their interest in mathematics. These discussions took place as a part of the regular classroom experience, and each group involved thus was small enough to encourage questions and comment from the students themselves. Such discussions would have failed of their purpose had we attempted to develop a specific interest in engineering. Rather emphasis was placed on the relevance of mathematics to many fields, a number of which, such as the skilled trades, do not require college training. Mathematics was described as a common denominator to a great number of vocations. It was emphasized repeatedly that those who do not take mathematics in high school automatically eliminate themselves from any later opportunity to enter any one of this large number of vocations. On the other hand, those students who do take mathematics are not eliminated from any future areas of work. The results of this first program have been so valuable to high-school students, and so helpful to guidance counsellors, that it is planned to continue it in the future. We need to extend it to the pre-high-school class to encourage more of them to take high-school algebra. This same result can be achieved in any community, large or small. It needs little more than the leadership and initiative of at least one individual to organize the activity. And in proportion to the results achieved, it really requires very little time and effort. Here is a specific program that should be one of the projects of each AIEE Section.

### ENGINEERING AND ITS COMPETITION

THE NEXT STAGE in the preparation of tomorrow's engineer, in which we as engineers have a great stake, is at the time when the high-school senior makes a decision with respect to entering college, and engineering college in particular. If we have done a good job in the earlier years, particularly in guiding the high-school student to prepare himself with adequate mathematics and science, he will have the necessary high-school prerequisites to qualify him for engineering college. The objective here then should be to give the high-school senior a picture of what engineering is, and the opportunities which it offers him for a career. Today there are many groups concerned with this problem. A large number of colleges are actively recruiting high-school seniors, and as an aid to such recruitment, several are developing comprehensive motion picture presentations illustrating the nature of engineering and the opportunities inherent in the profession. Such material is, naturally, directed toward a particular engineering school, and is sometimes heavily discounted by high-school seniors as propaganda. The professional societies rightly have a responsibility and an opportunity at this point. What can be done is illustrated by our own experience in Schenectady this winter. We brought together 400 high-school seniors, their teachers, and guidance counsellors, from 25 high schools in this area. The meeting was planned to occupy a full afternoon. Objectives of the meeting were

1. To inform all students of what the broad field of professional engineering represents.
2. To interest qualified students in engineering as an attractive profession.
3. To correct the impression of a surplus of engineers made by the 1950 release of the Bureau of Labor Statistics.
4. To give straight answers to questions the boys and their counsellors have regarding engineering, college, and so forth.

We attempted to accomplish these objectives by a brief talk, a motion picture illustrating engineering achievement, and a panel of high-school seniors and experienced engineers. The whole program was most informal but effective, particularly the panel discussion where high-school seniors put questions to experienced engineers and received frank answers to any and all questions. Those present were unusually enthusiastic and are insistent that we put on a whole series of such meetings next fall. I think it is well to emphasize that the program did not include any inspection trips. We felt that the effectiveness of such trips would be low in comparison with the type of program outlined. The results of our experience certainly verify this conclusion. Any professional society could well arrange for such a program, and I am sure it would be well received by the high schools. A very great factor in insuring the success of the program at Schenectady

this winter was the active participation of high-school principals and guidance counsellors in the planning of the program. Such meetings will add materially to the number of qualified boys and girls enrolling in engineering colleges. Local AIEE Sections should consider promoting meetings of this type each year. High-school principals and guidance counsellors naturally will carry the major responsibility for planning and organizing the meeting, but the initiative must come from us.

## EDUCATION FOR ENGINEERING

Although all of us as professional engineers and educators are most deeply concerned with the third and final phase of preparing tomorrow's engineer, we must not forget that our success at this point is as much, or more, determined by the ability and interest which entering freshmen bring to the college experience. While continuing to examine critically such college experience, we must recognize the degree to which we can improve the earlier phases of formal education by proper encouragement and counsel. With this firmly in mind then, we come now to a consideration of formal education for engineering.

Among the professions, engineers probably have been more critical of their education, and more concerned with its future improvement, than any other group. While such self-analysis has certainly aided in improving engineering education, it has given the impression, to the public at large and to many engineers as well, that engineering education is really quite unsatisfactory. The constant demands of industry for changes in engineering curriculum—for more public speaking, more economics courses, more social humanistic subjects—all create the impression that industry does not regard highly the job which the colleges have been and are doing. A careful examination will reveal, on the contrary, that such demands by industry arise from the desire to improve still more an already outstanding product—the engineering graduate. In spite of the pressure from industry for men with more nontechnical skills, we must not overlook the fact that industry still comes to the engineering college for these men, and not to other colleges. In our wish to provide good all-around graduates, we must not so reduce their technical proficiency as to make them almost indistinguishable from nonengineering graduates. The pressure from industry is constantly for men who can do more effective technical work. The colleges must be fundamentally concerned with meeting that need, a need which requires an even greater emphasis upon technical proficiency, as well as emphasis upon such skills as public speaking and others in the social-humanistic area.

We must examine critically the technical portions of the curriculum, not so much for the purpose of "finding time" for nontechnical courses as for improving the efficiency of technical education. The last report of the Committee on Adequacy and Standards of Engineering Education, of the Engineers' Council for Professional Development, of which Dean S. C. Hollister is chairman, emphasizes that there are certain specific features of the technical portion that can be accepted as most essential. The report describes these clearly and concisely in the following paragraphs:

"The first of these (features) has to do with courses least likely to obsolesce. While it is necessary to give a certain amount of instruction relating to the present state of the art, it is certain that the present state will change, and hence that time given to such courses is not time devoted to a subject of sustaining value. Sifting back through the curriculum, it seems clear that instruction in the basic sciences, if taught in a manner such that knowledge of them makes available working tools, contributes the most sustaining part of the curriculum. Among these basic sciences, the greatest potential for future development in science and technology is to be found in mathematics. An engineer with a good knowledge of mathematics is in a position to read with understanding and profit in physics and chemistry. Likewise, as his interest and need may expand, he may read further in the applied sciences, such as mechanics, elastic stability, advanced thermodynamics, or fluid mechanics. Similarly, new applications of sciences to engineering situations may be understood and assimilated. Thus, mathematics not only becomes the support of the group of courses that will obsolesce least; it becomes the means of further technical growth as befits the graduate's interest and need. Building into the program this and other means for further technical self-development of the individual after graduation is the second most important feature of a well-designed curriculum.

"The third feature that impresses your committee as of ranking importance has to do with the way in which the applied courses are related to those in basic and applied science. Two distinct approaches are discernible in present practices; one utilizes the engineering situations provided in the applied courses to illustrate the manner of employing the sciences in engineering work, while the other makes the applied courses the goal of the curriculum with the minimum of application of the sciences. The former builds into the student a power of analysis and resolution in engineering situations that permits a wide range of application. The latter tends toward the achievement of a series of skills intended to equip the student for specific jobs immediately upon, and soon after, graduation. The first is professional preparation, the second vocational training. What is involved is not alone the way in which individual courses are presented; it especially relates to the prevailing concept of the function of the whole curriculum."

I know of no better statement of the proper relation between scientific and applied courses in college than that which I have quoted. This statement is, I believe, one with which industry will heartily agree.

Although the point has been made many times, we still must not overlook the primary effect of good teaching upon the development of the very skills and attitudes which are included in this statement of curriculum design. Good teachers with a poorly organized curriculum can still do a remarkable job in education. But the best curriculum in the world will produce unsatisfactory results with poor or mediocre teaching. The American Society for Engineering Education has recognized this through the study it has made, during the past 2 years, on ways and means to improve teaching. Every one of us can recall good teachers that we have had, and ideas they have contributed to us, although we frequently have forgotten most, if not all, of the

particular subject which was their specialty. Dr. Harvey N. Davis has well described the attributes of a great teacher in these words:

"A great teacher is a man whose personality is so attractive, and whose character is so fine, that by unconscious tuition he wins the admiration and life-long devotion of his students and all unconsciously influences their ideals and molds their characters, so that they are forever after better men for having sat under him. What one learns from such a great teacher is often a by-product of minor importance, rather than the main object or chief advantage of taking his instruction. Would that every American college faculty might be composed wholly of such men."

### CURRENT EXPERIMENTS IN EDUCATION

Much study and discussion have been devoted to the merits of the 4- versus the 5-year curriculum. The fact alone that several outstanding colleges after such study have embarked upon a 5-year program indicates the need for a critical appraisal of its value before it can be properly compared with the 4-year program.

The effect upon the product of the engineering institutions, the graduate engineer, is the only accurate appraisal we can make of any program, and it should be applied here. Too much thought has been devoted to this problem for us to attempt to reach definite conclusions where others have hesitated to do so. A complete answer must wait until graduates of the 5-year program have been in industry long enough to be compared with those from the conventional 4-year curriculum. I question whether we can honestly give an answer now to the question, "Should engineering education be generally extended to 5 years?"

On the other hand, we can, and should, reach some conclusions as to the extent of the experiment in engineering education which we are conducting. We should be extremely foolish if in the laboratory we used all of our supply of a precious metal in conducting a single experiment. Rather, we would experiment successively with as small a portion of that metal as we could use to determine the validity of the experimental results. In a similar fashion, we should not extend the number of institutions with 5-year curricula until we have proved experimentally the value of such a program. I doubt whether we shall have any answer which is at all conclusive for at least a decade. It is just as important for those colleges with 4-year programs to continue them, to revise and improve them, as it has been for certain colleges to pioneer in the organization of a 5-year curriculum.

But what of the problem which originally created the need for a 5-year curriculum, namely, the concern of the profession for the education of undergraduates in social and humanistic areas. I think we must recognize the limitation of the present educational method as it applies to this area particularly. The course method of instruction tends to assume that an individual can be divided into a number of different segments which can be educated independently and then reassembled into a composite fully educated person. Thus, we give a man a course in heat transfer in which we are frequently careless about his use of English and his organization of information in answering questions or solving problems. In fact, the engineering instructor may often have little appreciation himself of the importance of English in engineering and so insidiously convey that impression to his students. Conversely, in a course in English composition, there is but negative appreciation of a theme describing a technical problem and even a tendency to exclude technical subjects from discussion entirely. It is hardly surprising that the engineering student has but scant interest in English or other liberal subjects, and has little or no understanding of their value to him as an engineer.

Whether we can do very much in teaching liberal subjects to men at this time in their lives I seriously question. Fundamental principles of science and engineering can be demonstrated physically in the laboratory, and definitely established to the satisfaction of the student. How can he appreciate, on the other hand, what it means to solve a problem in labor relations when he has never worked in a plant or had any experience of living to appreciate the problem involved? Sir Richard Livingston in his book, "On Education," expresses this well in these words: ". . . . you cannot study fruitfully certain subjects, among them philosophy and politics, unless you know something of life. On the other hand, there are subjects, such as mathematics, of which a boy or undergraduate is fully capable, even if he knows nothing outside the walls of his home, school, or university. For whereas politics and ethics are concrete, mathematics is purely abstract and theoretic, and does not spring from life or need experience of life to illuminate or correct it."

Our aim in broadening the base of undergraduate engineering education should be not so much to teach the engineering student specific knowledge as to make him aware of the importance of English, economics, and psychology, not only to others, but to him as an engineer. If he develops an appreciation of these fields as a student, he will naturally continue his study of them far beyond the period of his formal education. In our present industrial society, this is the very period in which he begins to have a need for additional education of a largely nontechnical character.

It should be clear that there is potentially as great an opportunity to create awareness of the value of liberal education indirectly through the attitudes of the engineering faculty as directly by specific courses. It has, in fact, been humorously suggested that the engineering faculty be given the courses in liberal subjects rather than the students. Perhaps there is some real value in this suggestion.

If in any particular case, however, a college determines to attack this problem indirectly through the attitudes of its teaching staff, a definite plan is essential to achieve any measurable improvement. The great danger is that the indirect approach to a solution will be so haphazard and vague that it will be essentially without plan or purpose, almost without any critical and continuous evaluation.

I have emphasized earlier the importance of concentrating on courses least likely to obsolesce and the fact that such courses are fundamentally those in the basic sciences. Since instruction in basic sciences is not confined within a particular branch of engineering, some colleges are giving serious consideration to planning a common undergraduate curriculum. There is little question but what the objec-

tives of such a common curriculum are well in accord with the fundamental concepts of curriculum design described earlier. The real test is whether the common curriculum can maintain a high level of technical content, compared with specialized curricula, and can also provide sufficient motivation to stimulate engineering undergraduates. Most of the objections which have been raised concerning the common curriculum are related to this latter problem. It is stated with emphasis by many educators that engineering students do not come to college to take engineering in general, but rather a particular branch of engineering. If students did not feel they had ahead of them an opportunity to specialize in the branch of their choice, they would never enroll in an engineering college at all, runs the argument. I doubt, however, that we are actually making effective use of this particular motivation even if it is a real factor in encouraging and stimulating undergraduates. Most colleges today insist that freshmen and sophomores shall study fundamental subjects, such as mathematics and basic sciences. For at least 2 years, therefore, there is no real contact with engineering, let alone with a particular branch of engineering. Perhaps it is the lack of any applied courses in this period that is partially responsible for the high mortality among freshmen and sophomores. I have even, on occasion, suggested that perhaps we should give our specialized and applied courses in the early years, capitalizing on the motivation claimed as the advantage of specialized curricula. Then from such special applications, the basic scientific and mathematical principles could be derived. Basically, we learn from experience and specific situations and then from these we draw a general conclusion or enunciate a principle. We have tried too frequently to state such general principles for the student without permitting him the inspiration and challenge of discovering them for himself. Such an educational process is, by no means, a simple one, but it may well be the most effective and successful one. If the interest and discussion aroused by current experiments with common engineering curricula serve to make all of us re-evaluate the whole pattern of engineering education, they will have been infinitely worth while. If they also encourage a school, here and there, to try experiments in curriculum design such as the radical suggestion which I made earlier, we may very well find ways to make greater improvements in engineering education than we have for several decades.

Even within the confines of present engineering curricula, however, a much greater degree of emphasis upon the fundamentals of science and mathematics can be achieved, provided the specialties of particular engineering fields can be subordinated to the over-all objective of educating an engineer. The Committee on Improvement of Teaching of the American Society for Engineering Education has suggested that common educational practice falls short in the use of basic laws, and has stated several ways by which the teaching procedure can be improved. Since the student learns by doing, most effective teaching depends upon the proper use of comprehensive problems. Such problems should have the following characteristics:

1. Problems in which the student on his own initiative arrives at conclusions by use of basic laws or extends the use of a basic law.

2. Problems devised so that the student must decide what will be his method of attack.

3. Problems that deal with real situations, so that motivation is provided by a sense of accomplishment when the student reaches a conclusion.

4. Since problems in practice are assigned in general terms, sometimes orally, or in many cases have to be discovered by the man himself, some problems in class should be assigned orally. Then the student's first step is to clarify the situation and discover and state his immediate goal for himself.

5. The problems should be carefully examined by the teacher, comments noted on the paper, promptly returned, and discussed fully in class.

Thus, we return to the importance of the teacher and the teaching attitude in the whole educational process. While proper course and curriculum design can serve to outline the process of engineering education, it can only be made effective as the teacher believes in its objectives and carries them out.

## RESPONSIBILITY AND OPPORTUNITY

Engineering education has behind it a long heritage of success in providing college graduates with good foundations for professional careers. It is, in fact, this same successful performance which has contributed most directly to our present engineering manpower shortage, as industry has recognized how much engineering graduates can contribute.

In such times as these, we must be more concerned than ever before with the whole process of preparing the engineer. We must go back even to the extent of interesting ourselves in the conditions under which, as a child, he develops an interest in things scientific. We must show more concern for the early years of his formal educational development. And we must be especially conscious of the needs of students in secondary education for guidance and counsel. We must interest them in taking as much mathematics and science as they can handle, not only as a preparation for engineering, but also for any one of the semitechnical or skilled trades which play such an important part in industrial organization today. As individuals working in our respective communities, we can improve substantially the present interest in mathematics and science, and so almost guarantee a larger and more qualified group of prospective college students.

In spite of the present effectiveness of engineering education, we can see many ways of strengthening and improving it, some of which are so comprehensive as to constitute a revolution in educational thinking. If we can but convert to practice a fractional part of the potential improvement we see in the future, then reduction in numbers of engineering graduates will be more than offset by the superior ability of those men which the engineering colleges are able to furnish to industry.

Such is the challenge, and such should be our objective as educators and as professional engineers.

# Tomorrow's Engineer—In Use

GUY KLEIS

**The present and future shortage of engineers is given consideration in respect to possible remedies. Ways of utilizing more efficiently the available engineers are emphasized. The importance of industrial training programs and continued education to keep up with the advances being made at an ever-increasing rate in the engineering field are stressed.**

CERTAIN TRENDS have been developing during recent years that promise greatly improved economic and professional status for the engineer of tomorrow. While the trends in question are natural, thus inevitable, they have been markedly hastened by two sets of circumstances: the tremendous acceleration of technological progress during World War II, and the shortage of trained engineers that has existed during the past decade and threatens to continue through most of the next.

The fact of unprecedented technological advance without attendant availability of new engineers clearly indicates a need for rapid training and upgrading of new engineers when they do become available. Exactly this happened immediately after World War II in many companies. Returning veterans, who had traded cap and gown for uniform, were brought into industry, given brief but intensive training, and were quickly placed in positions of heavy responsibility, a situation born of urgency. This condition has prevailed to a degree ever since, because the needs of industry have never been completely satisfied. Even the record college crop of 1950 was 70 per cent absorbed before graduation (which was before Korea) and the remaining 30 per cent was gobbled up in the next few months. The manpower situation now has become so acute that more and more employers are doing more and more to better train and better utilize the engineers they already have and the trickle of new ones they are able to hire. The "more and more" now being done by employers of engineers undoubtedly should enhance greatly the professional status of tomorrow's engineer.

The engineer always has been taken too much for granted, both by industry and the public. He has been a victim of a law that cannot be repealed, the law of supply and demand. Not until World War II has industry ever had to worry about the availability of new engineers. Supply always exceeded demand. This fact also pegged engineers' salaries at a relatively low level. In our competitive economy, the determination of the salary level for a certain skill follows the supply and demand law as naturally as the determination of selling price for a manufactured product.

Now at long last, the engineer is in short supply, the position he always has thought would be the answer to his problems. Perhaps it is. There are some who say: "Let us keep it this way. Let us limit the number entering the profession each year so we will remain in favorable unbalance with demand. At least one profession has done this successfully for years." But the engineering profession is too far-sighted to employ such tactics. Already they are spearheading a campaign to encourage all well-qualified secondary school graduates to undertake an engineering education. The engineer has raised the technological level of industry to a point where 30 to 40 thousand new engineers are required each year to perpetuate this progress. Since the future of democracy is absolutely dependent on our technological superiority, the engineering profession, true to its colors, is rallying to the cause and doing all it can to lick the shortage, and thus maintain superiority.

In spite of all efforts to recruit young men for engineering education, it looks as though, with the possible exception of a few lean years, there always will be a shortage of engineers. Industry is expanding unbelievably, and at the same time the ratio of engineers to total working force has changed from 1 in 250 in 1900 to 1 in 100 by 1930 and is approaching 1 in 50 today. Losses to the profession through death and retirement will increase each year, reflecting the successively larger groups that had entered engineering annually 40-odd years ago. Adding to this picture is the rather alarming information which has been brought out by Dean Hollister:[1]

"How do we obtain not less than 30,000 graduates yearly? First of all, to do so requires an annual input of 60,000 freshmen. This is about double the number entering engineering schools this year. . . . On the basis of an average high school output of 1,200,000 boys and girls, 5 per cent would be required to produce 60,000 engineering freshmen. This is about 10 per cent of the boys graduating from high school. There is some doubt whether the combined factors of aptitude, ability, and interest would be found in so high a percentage. It seems possible that 60,000 freshmen may be at or above the available number that can be expected to enter engineering. This brings home the fact that there is not, and there cannot be developed, an inexhaustible supply of engineering talent, but instead the supply is sharply limited."

What does all this lead to? What is being done to spread the present engineers thin enough to handle the job at hand? What plans are being made to meet the acute shortage as its effects compound in the next few years? What lasting effect will there be on the profession? What

Full text of District paper recommended for publication by the AIEE Committee on Education and presented at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. The companion article, "Tomorrow's Engineer—In Preparation," by K. B. McEachron, Jr., appears in this issue, pages 597–602.

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are these favorable trends mentioned in the opening paragraph of this article?

## BETTER UTILIZATION OF ENGINEERS

As a prelude to discussion of utilization, a medical analogy may be of illustrative value. A young doctor sets up a private practice and struggles along for a short while with a limited following. He finds it necessary to handle all phases of his work without assistance, for economic reasons. Before long, however, word gets around that he is a good doctor and that you do not have to wait in his office as long as you do in most. The populace in the community then starts readjusting allegiances and our young doctor finds himself with more work than he can possibly handle, just like the other doctors. He then hires a combination nurse-secretary-receptionist to help him out. As business continues to boom, he finds it necessary to employ a full-time nurse and a full-time secretary-receptionist. Eventually he hires another nurse, a full-time secretary, and a full-time receptionist. Through this evolution, the doctor has limited his range of professional endeavors to a narrow band. He no longer spends time arranging appointments, answering telephones, doing the office bookkeeping, treating minor cuts and bruises, preparing instruments, bandaging, doing routine analyses, and so forth. He has delegated all this to clerks and technicians. He also equips his office with modern medical tools to ease his loading further. Our doctor now finds that he can handle more than twice as many patients as he could originally.

The moral of this story is obvious. The range of the engineer's professional endeavor must be narrowed considerably. He must be given all the clerical assistance he needs and he should have suitable help available to handle routine computing, drafting, laboratory testing, model building, expediting, writing routine reports, and so forth. The engineer's total time should be available for creative, analytical, consulting, and administrative work.

It is encouraging to hear reports coming in from many quarters that industry already is making moves toward better utilization of engineers. One company has established an administrative engineering staff which is made up entirely of clerical personnel. This staff has taken over all of the nontechnical detail work for an engineering department numbering over 200 men. The company claims that their engineering job now can be performed by 30 per cent fewer engineers.

Many companies that formerly made a practice of hiring engineers for drafting jobs and test floor work now are filling such positions from other sources. Many are hiring technical institute graduates, but here, too, a tremendous shortage exists. To supplement this source, some organizations are running training programs through which high school graduates are brought up to a satisfactory level for this type of work.

There is a broad area in industry in which the employment of engineers is highly desirable but not absolutely necessary. This area includes many positions in manufacturing, such as quality control, production planning, and time study; also positions in sales where the products and application thereof are not too technical in nature. To help fill the manpower needs in this area, many companies are employing graduates in business administration and liberal arts. Intensive training programs, to supply the necessary basic engineering concepts, are tailor-made to fit their particular needs. The rounded background of the liberal arts and business administration graduate is ideal for jobs in this area, so it is likely that industry will continue to fill such jobs with nonengineers in the future.

Another method being used to relieve the situation involves the use of improved physical tools. Modern computing machines can relieve the engineer of hours and hours of routine, repetitive calculating and, in fact, can perform some calculations that are impossible to solve accurately by the long-hand method. For example, a new analogue computer for making turbine blade calculations can do a job in two weeks that would require $1^1/_2$ years in long hand. On transient torque problems in generator design, the ratio is about 20 to 1 in favor of the computer. A network calculator for analyzing transmission and distribution systems shows a similar saving in engineers' time. A typical study that can be set up and run off in 2 days would require 2 solid months of slide-rule calculations to solve.

Many companies are restudying the structure of their entire engineering organization to spot any duplications of effort that may exist and to clear any bottlenecks in communication channels. All too frequently, there is duplication of planning between headquarters locations and outlying plants or offices. Physical changes in office arrangements or moving laboratories and technical libraries to central locations save many engineer-hours every day.

All these attempts at relieving the effects of the engineering manpower shortage represent a trend toward utilizing the engineer at a higher level and in a more clearly defined band of activities. These actions have not reached any sizeable proportion thus far, but a good start has been made. This trend is bound to grow during the next several years as the continued and more acute shortage forces the issue. The gains in the status of the engineer should be lasting, not only because of continued shortage, but also because the programs that are bringing about these gains are improvements which employers will not wish to discard.

## INDUSTRIAL TRAINING PROGRAMS FOR ENGINEERING GRADUATES

A good training program has proved to be an effective instrument for assuring maximum utilization of new engineering graduates entering industry. While it is difficult and sometimes painful to institute better utilization measures among experienced engineering groups, the new engineers joining a department can be properly indoctrinated and placed in a clearly defined position at the outset. An intensive orientation and training period affords a smooth transition from academic to industrial life and provides the opportunity to place each graduate in a permanent position which is compatible with his best interests and qualifications. Such a program necessitates a short delay in taking on definite job responsibilities, but the delay is more than offset by the greater productivity and more rapid professional growth which inevitably results when a man is doing a job he likes to do and does well.

Prior to World War II, training programs were considered in the luxury class by many companies. The companies that sponsored such programs, on the other hand, looked upon good recruitment and training as an extremely wise investment which paid rich dividends in organizational strength. Polls taken in senior classes of engineering schools always have indicated an overwhelming preference for employment with a company which offers a good training program. It was for this reason that more and more employers of engineers instituted industrial training programs immediately after World War II. It was bait needed to procure top quality graduates in a short supply market.

It is gratifying to hear the reactions of employers who have gained some experience in training. None of them considers his program as a temporary measure, although that may have been the intent at the start. They have found that a host of benefits have accrued to both themselves and their new engineers as a direct result of the training course. Following is a partial list of these benefits:

1. Supplies the necessary quota of high-potential young men without which a company cannot exist in this highly competitive age.
2. Provides a background on the industry in which the young graduate now finds himself, and makes clear at the outset the organization, policies, and objectives of the company of which he is now a part.
3. Imparts a broad familiarization with the products and services of the company so that each man has a good knowledge of over-all company operations. As a result, he can readily see how his first productive job, no matter how specialized, fits into the over-all scheme.
4. Develops a real company loyalty in the trainees because of management's obvious investment in time, money, interest, and patience.
5. Greatly influences behavior patterns of trainees, through close association with many older experienced fellow employees who have wide professional recognition.
6. Tends to instill healthy attitudes, through heavy emphasis on opportunity and the rewards of doing a job. Most trainees soon become convinced that security is a by-product of top potential performance.
7. Enables the trainee, under guidance, to explore all possible job opportunities so that ultimate placement can be arranged in an activity that best matches the individual's interest and qualifications.
8. Keeps turnover low. This fact alone justifies the expense of a training program, according to reports from several companies, both large and small, who have long experience in training.
9. Produces top management people. Many companies with time-tested programs point with pride to the fact that almost all of their management personnel, from top to bottom, or conversely, are products of their training program.
10. Assures utilization of engineering and scientific manpower at maximum potential; an important consideration in days of critical manpower shortage.
11. Provides motivation to the individual to follow a continuous personal improvement program. Good study habits have been preserved. The realization has been awakened that entrance into industry is but the beginning of another phase of his lifelong education. He is fully convinced that education is a journey, not a destination.

## PROGRAMS OF CONTINUED EDUCATION

The last-named item paves the way for discussion of still another field of education that is fast catching on in this country. Continued education as referred to here is entirely apart from industrial training; it represents continued academic work in advanced fundamentals. Obviously, the need for such programs increases directly with technological progress. The young engineers of today recognize the need for certain advanced courses soon after they get into their first permanent positions, and are demanding that continued educational opportunities be made available to them.

Here again a desirable activity was nudged into action by the engineering manpower shortage. Many of the top-notch engineering graduates would not accept employment with a company that did not provide opportunity for graduate-level study. As a result, many employers worked out arrangements with local universities to make desirable course offerings available in the late afternoon and evening. At the present time, there are about 15 areas in the country where fairly extensive adult and professional educational programs exist. The responsibility for organizing such programs has been taken on by the university, industry, and the technical societies. In most cases, industry provides encouragement to the young engineer to participate in the programs by refunding at least a portion of the tuition and by helping make desired courses available. Programs of continued education also tie in closely with good utilization of engineering talent. The young engineer is better preparing himself for the field in which he is working, thereby speeding his readiness to take increased responsibility.

## IN CONCLUSION

This article has pointed up some of the desirable trends which are under way in the engineering profession today. Though born of urgency, these trends will continue and the effects promise to be of lasting value.

The experienced engineer of today can expect that a higher percentage of his total work will fall in a more clearly defined band at a higher professional level. The new engineering graduate who enters industry will have the benefit of a well-planned training program, placement in a job that best matches his abilities and interests, and the advantages of a continued educational program in his community. His professional development will be encouraged and abetted by his employer and by his technical societies. His status in the community, both professionally and economically, will be on a par with the other professions.

This sounds too idealistic? Perhaps so, but the movement is under way and there is no good reason why it should stop before fulfillment.

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# Transpositions and Unbalance of High-Voltage Lines

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UNTIL ABOUT 20 years ago, transmission engineers felt that transpositions at fairly close intervals were a necessity on high-voltage lines in order to co-ordinate communication and power systems. However, in many large high-voltage systems, the number of transposition structures has been reduced greatly and the matter of co-ordination has not produced any difficulties. Many new lines have been built with no transpositions, and remedial measures necessary for inductive co-ordination have been few since these lines were placed in service. The change in practice is the result of several factors. Separate rights of way for communication and power lines, use of underground cables or otherwise shielded circuits for communication purposes, reduced susceptibility of the communication equipment to noise, and improved designs of transformers and rotating machines leading to better wave shapes are some of the reasons.

The trend toward reducing the number of transpositions on line sections also is based on the experience that on some systems not less than one out of four faults was associated physically with a transposition. In addition, elimination of transpositions and the necessary structures leads to savings. The newer practice has been to introduce transpositions only in or near switchyards by rearrangement of phases.

It is difficult to arrange the conductors of a 3-phase transmission line on the towers in such a manner that both the electric and magnetic fields are symmetrical. Complete transposition produces a high degree of balance between the ends of lines or line-sections so transposed. Omitting transpositions between stations therefore will enlarge the effects of the geometric unbalance of the conductor configuration. As a result of electrostatic or magnetic unbalance, circulating residual currents will flow in high-voltage systems with solidly grounded neutrals. In high-impedance and resonant grounded systems, voltages between system neutral and ground (neutral displacements) will be produced. However, the unbalance is not restricted to residual or zero-sequence quantities; negative-sequence charging currents as well as magnetically induced zero- and negative-sequence currents[1] will flow through the lines, and negative-sequence currents also will flow through the windings of terminal equipment, such as transformers and rotating machines.

The unbalance may be analyzed by considering electrostatic and electromagnetic effects independently. Electromagnetic effects depend on the load currents, whereas electrostatic effects are present under all conditions and are therefore of prime interest.

This investigation is confined to zero-sequence currents $I_{a0}$ produced by electrostatic unbalance of the line in solidly grounded systems. The ground displacement, $d_0 = I_u/I_G$, is computed from the geometric configuration of typical single and double circuit lines. The ground-fault current $I_G$ can be evaluated easily from the zero-sequence capacitive line-reactance $X_0'$ and the phase voltage $E_1$. The circulating residual current is then $I_u = 3I_{a0} = d_0 I_G$.

The unbalance of typical conductor arrangements is influenced by the addition of ground wires. On lines with conductors arranged horizontally, a reduction in $d_0$ is brought about by ground wires with good shielding angle, and also by an increase in the ratio of the horizontal spacing between phase wires to their average height above ground.

Vertical arrangement of phase conductors leads to larger unbalances, but interchanging only two particular conductors reduces $d_0$ considerably.

On double circuit lines, better electrostatic balance to ground will be achieved if conductors that are located symmetrically with respect to the towers do not carry the same phases, see Figure 1. Without ground wires, Figure 1*A*, the two highest conductors should be connected to the same phase, *A*, on both sides of the tower. With one or two ground wires, better balance may result from the arrangements indicated in Figure 1*B* to 1*D*.

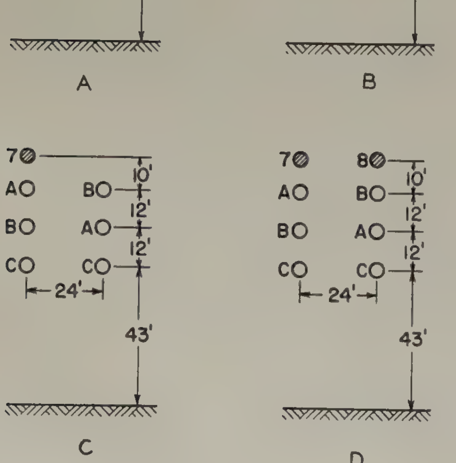


**Figure 1. Double circuit lines**

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# The Closed Core Reactor

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FOR APPLICATIONS which require a rapid increase of reactive kilovolt-amperes with moderate increase in voltage, a reactor with a closed iron core represents a practical solution. By operating the core slightly below saturation, moderate increments in applied voltage will produce large increments of current by forcing the core to operate above saturation for portions of a cycle.

In the application of reactors of this type, the fundamental component and the total rms value of exciting current are of primary importance. As both of these quantities are determined almost entirely by the current peaks, it is possible to analyze the performance with engineering accuracy by assuming the impedance infinite below core saturation. The theoretical relations used are based on a hypothetical reactor whose core has a broken straight-line characteristic.

If a gradually increasing sine voltage is applied across this hypothetical reactor, the current will remain zero until an rms value $(E_s)_{\text{rms}}$ sufficient to bring the core to the effective saturation flux density $B_s$ is reached. This represents the transition point between the two straight-line portions of the core characteristic. Beyond this point, the exciting current appears as a series of discrete positive and negative pulses. In this current region beyond saturation, the reactor has an impedance $Z$, determined by the effective resistance $R$ and the air core reactance $X$ of the winding.

The rms value of the total exciting current and its fundamental component can be expressed in the form

$$(I_T)_{\text{rms}} = K_T \frac{E_{\text{rms}}}{Z}$$

$$(I_F)_{\text{rms}} = K_F \frac{E_{\text{rms}}}{Z}$$

where $Z = \sqrt{R^2 + X^2}$ and $E_{\text{rms}}$ = rms value of applied voltage.

The coefficients $K_T$ and $K_F$ introduced here are completely determined by two simple nondimensional ratios. These may be defined as

$$n = R/X \text{ and } s = \frac{E_{\text{rms}}}{(E_s)_{\text{rms}}}$$

Plotting the characteristic curves in terms of $n$ and $s$ places them in generalized form applicable to any closed core reactor.

As the fundamental component is in general the useful component of the reactor current, the ratio $p$ of the fundamental to the total rms current is indicative of the effectiveness of the reactor.

$$p = \frac{K_F}{K_T}$$

The ratio $p$ is plotted in Figure 1 for values of $n$ of zero, five, and infinity. The fundamental component of the exciting current is relatively large.

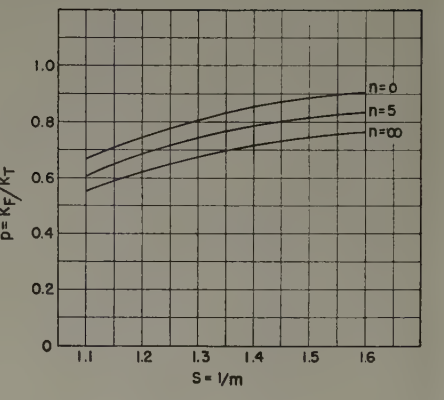


**Figure 1. Ratio of fundamental to total current as a function of the excursion beyond core saturation**

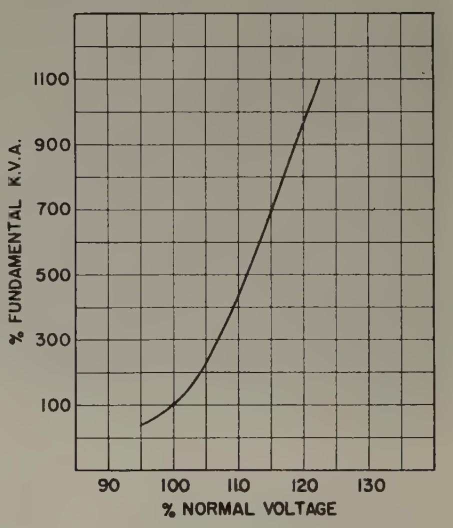


**Figure 2. Operating curve of closed core reactor**

One of the problems encountered in the use of a closed iron core reactor operated in the neighborhood of saturation is the high inrush current which may flow when voltage is first applied. The simplest method of controlling the inrush is to use a series resistor. This not only limits the magnitude of the inrush, but decreases the duration of the transient. Fortunately, the resistor may have a value considerably greater than the air core reactance and still produce only a moderate reduction in the fundamental component of reactor current.

Figure 2 illustrates the operating curve of a commercial reactor of this type. The voltage and kilovolt-amperes designated as 100 per cent correspond to an operating point slightly below core saturation. At 110 per cent voltage, the fundamental kilovolt-ampere has risen to over 400 per cent. This sharp transition at saturation is a basic characteristic of this type of reactor.

Digest of paper 51-375, "The Closed Core Reactor," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cleveland, Ohio, October 22–26, 1951. Published in AIEE *Transactions*, volume 70, part II, 1951, pages 2026–9.

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# New High-Capacity Switchgear Testing Laboratory

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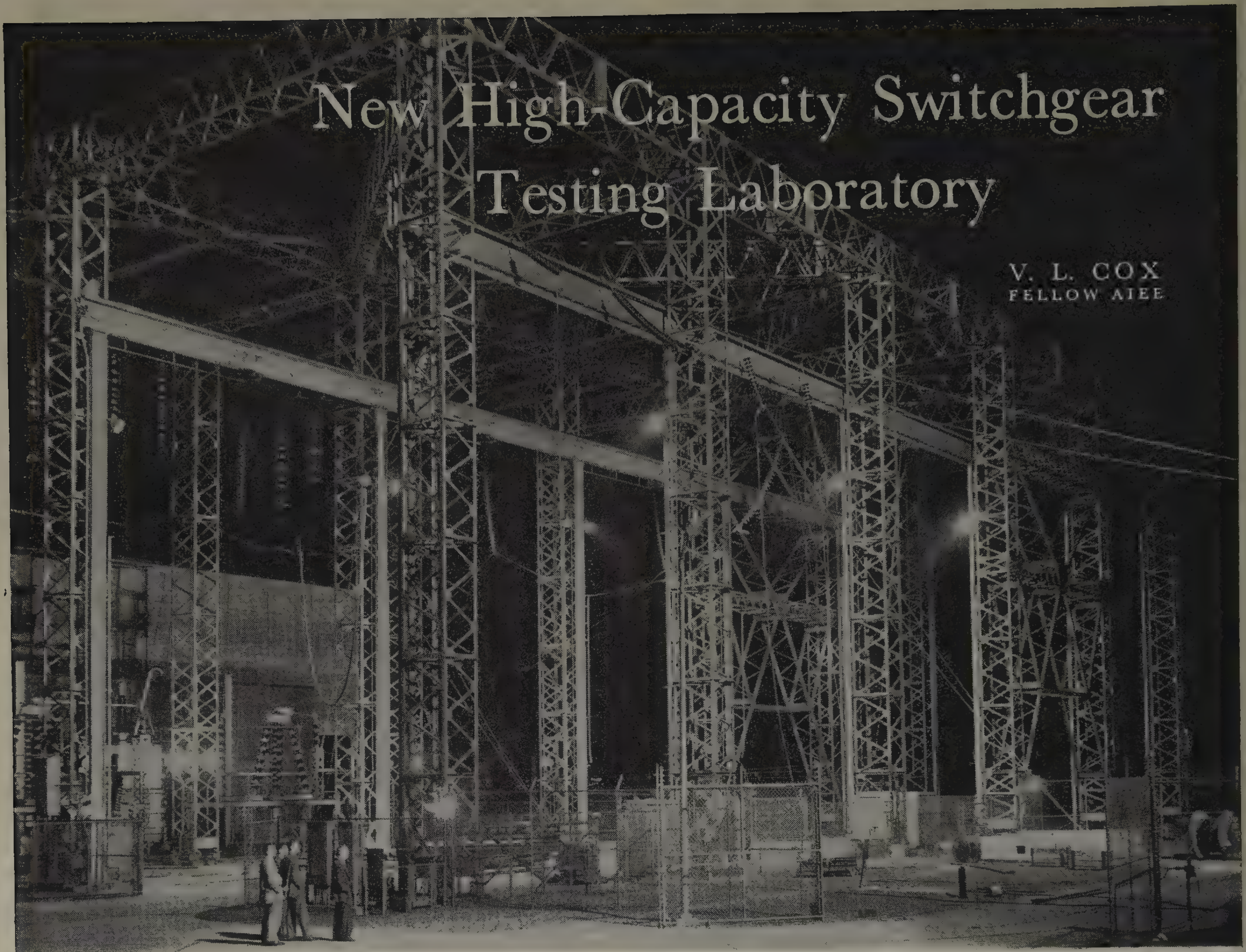

A HIGH - CAPACITY switchgear testing laboratory has been placed in operation recently by the Switchgear Department of the General Electric Company. This new laboratory is located about a mile from, and within sight of, the switchgear factory near the southwest boundary of Philadelphia, Pa. It is situated on a ground area of about 20 acres on which are placed the buildings which house the various parts of the equipment, including the two largest generators that have been built for short-circuit testing. An aerial view of the laboratory is shown in Figure 1.

**This new high-capacity switchgear development laboratory is considered a necessary adjunct to the company's engineering and manufacturing facilities. It will be used primarily for circuit interrupter development, but it can perform many types of tests.**

The two testing generators have been designed, when operating in parallel, to deliver a total of 3,200,000 kva symmetrical in the first 1/4 cycle, 3 phase at the 15.5-kv bus in each of the 5 test cells. These 1,800-rpm generators, each nominally rated 125,000 kva, have been designed with an unusually low slope decrement so that the symmetrical current at the end of 5 cycles is still approximately 75 per cent of the initial symmetrical short-circuit value. Two 100,000-kva single-phase power transformers with unusually low reactance are used to supply the high-voltage test yard up to 440 kv single phase and 220 kv 3 phase (380 kv future). Three 24,000-kva single-phase transformers can supply currents as high as 400,000 amperes symmetrical in one of the test cells up to 1,200 volts. Two 10,800-kva capacitor banks form a part of the high-voltage yard for use in capacitor bank and line switching tests. Provision has been made for the installation of a third 100,000-kva single-phase power transformer, and for equipment for cold-room and load-life testing. Provision has been made for super-excitation of the testing generators, when found desirable.

There are no precise terms in which the maximum proof-testing capability of a short-circuit testing laboratory can be stated. This is because of the variety of methods

Revised text of paper **52-20**, "New High-Capacity Switchgear Testing Laboratory," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Acknowledgement is made to the General Electric Realty Corporation, Schenectady, N. Y., and United Engineers and Constructors, Philadelphia, Pa., for their assistance in the over-all planning, co-ordinating, construction, and installation of apparatus in this modern testing laboratory.

employed to conduct tests and the different objectives of tests. There are several well-recognized methods of utilizing a testing laboratory to demonstrate the interrupting ability of circuit interrupters having ratings far in excess of the full-voltage 3-phase short-circuit current which it can produce. The testing laboratory described in this article, both due to its high capacity and its modern facilities, is superbly adapted for all sound methods of direct and indirect circuit-breaker testing which involve the use of multiplying factors. Hence, its design is such that it gives full assurance that circuit breakers and other high-current devices now in development or anticipated in the foreseeable future can be adequately tested.

The choice of test voltages in this station was made to conform as closely as possible to the Edison Electric Institute–National Electrical Manufacturers' Association report on "Preferred Voltage Ratings for A-C Systems and Equipment"[1] in order that circuit breakers can be tested up to the maximum design voltage value listed.

## ENGINEERING OBJECTIVES

Since the installation of the first switchgear testing laboratory[2] in Schenectady, N. Y., in 1921, and the second Schenectady laboratory[3] in 1928, approximately 300,000 tests have been made either to prove designs or to develop better interrupting techniques. With a testing laboratory having a generator source only one-fifth the capacity of this new laboratory, high-voltage power circuit breakers capable of interrupting 12,000,000 kva at 230 kv[4] have been developed and performance confirmed by field tests without design changes. This was done by the use of well-known direct and indirect testing methods as well as by extrapolation procedures.

While this successful performance by General Electric development and design engineers has been commendable, it was deemed necessary recently to design and build a new short-circuit testing laboratory for several important reasons, of which the major ones are

1. To develop circuit interrupters of higher ratings made necessary by the phenomenal growth and interconnection of power systems.
2. To more nearly approach circuit interrupter ratings by increased capacity of testing facilities.
3. To make available more efficient facilities in order that more tests can be made in a given time to speed up development projects.
4. To study the effect of phenomena which affect switchgear devices in general and circuit interrupters in particular.
5. To reduce cost factors through investigation and a more complete understanding of arc phenomena and mechanical design.
6. To consolidate testing laboratory operation in Philadelphia together with all switchgear engineering and manufacturing functions.

Successful development of new designs or improvement of existing designs is the result of many factors, but in the circuit interrupter field this success is basically dependent on the availability of adequate testing facilities. In the 30 years since our first short-circuit testing laboratory was placed in operation and followed by others in the United States and abroad, many major improvements in switchgear have been made. It is expected that future requirements of the industry and design trends will be toward still higher voltage, current, and interrupting ratings; shorter opening, arcing, closing, and reclosing times; reduction in oil content; and improved operating mechanisms.

Field testing of circuit breakers has contributed greatly to the proving of higher interrupting ratings, but development investigation and testing in a laboratory under controlled conditions give greater assurance of adequate design and successful performance.

## PHYSICAL ARRANGEMENTS

Figure 1 shows the control building in the foreground, the main building in the background, and the high-voltage test yard to the right.

The control building houses the centralized control and instrumentation equipment as well as the administrative functions. This building is air conditioned with modern appointments. One side affords a panoramic view of all test areas through shatterproof windows. The test operator is thereby afforded a protected and unobstructed view of the apparatus being tested, which allows prompt disposition of any unfavorable developments and provides a visual check of personnel safeguards in the test area shown in the title photograph.

The main building is divided into two parts: one contains the incoming power source equipment, distribution equipment, testing generators, exciters, reactors, bus runs, circuit breakers, and auxiliary service apparatus; while the other part contains the machine and assembly shop where apparatus is prepared for test including assembly on test cars, mechanical adjustments, and repair, when necessary.

Five test cells are located in full view of operations along one side of this building. Three of these cells form test area number 1, while the other two form test area number 2. Isolated phase bus connections from the testing generators and generator circuit breakers terminate in these cells, which open toward and in full view of the operator in the control building and assistants in the

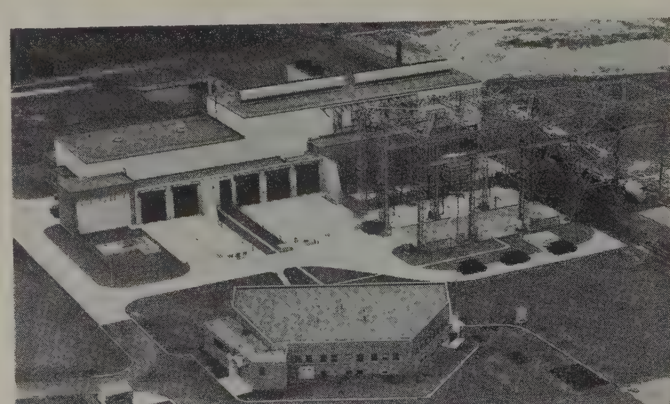
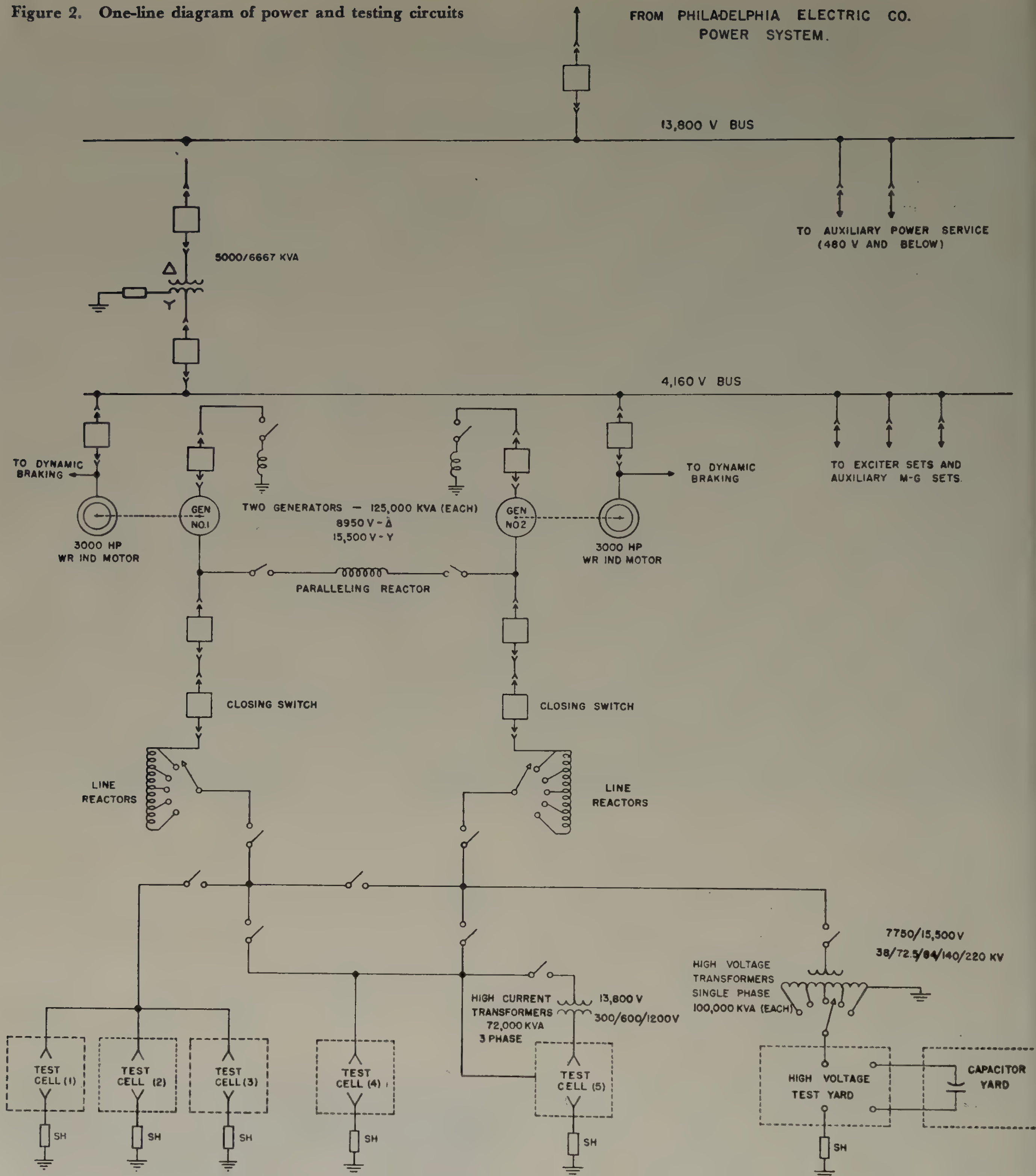


**Figure 1. Aerial view of development laboratory showing control and main buildings, test cells, and high-voltage test yard**

Figure 2. One-line diagram of power and testing circuits




observation booths. Tests up to and including 15.5 kv are made in these cells.

The high-voltage test yard forming test area number 3 includes the power transformers, disconnecting and tap switches, lightning arrestors, capacitors, and high-voltage connections for tests above 15.5 kv and up to 440 kv.

Two observation booths are located partially below ground in the area between the test cells, high yard, and control building. An underground tunnel connects the main building with the control building for convenient access and to carry all interconnecting electric conductors, steam lines, and pneumatic tubes.

## ONE-LINE DIAGRAM

The simplified 1-line diagram in Figure 2 shows the principal apparatus. Incoming power is delivered to the laboratory by the Philadelphia Electric Company from a nearby substation at 13.8 kv. At the laboratory this service is converted to 4,160 volts for 3,000-horsepower driving motors of testing generators, 480 volts for auxiliary

services, 120 volts for lighting and small motors, 125/250 volts direct current for shop circuits, excitation, and so forth.

Connections from each testing generator extend through a backup circuit breaker, synchronous closing switch, line reactors, and then to the test cell distribution bus, and to the primaries of the high-voltage transformers. Neutral circuit breakers are used with each generator connected in the Y point or inside the delta to provide for differential and ground protection of the generator. Paralleling connections are made directly at the generator terminals through a paralleling reactor so that this operation can be performed before the circuits are closed to the test cells. Paralleling is done before excitation is applied and synchronism is achieved simultaneously with voltage build-up. All setup switching is done with electrically operated disconnecting switches with the generator circuit breakers open and connections de-energized.

All switching operations associated with the incoming and distribution power supply are performed at the switchgear units serving those circuits. Switching operations associated with the test circuits are initiated from the master control benchboard, Figure 3, in the control building.

## SWITCHING EQUIPMENT

ALL INDOOR SWITCHING equipment is dead front and metal enclosed. All circuit breakers are of the removable type so that planned maintenance can be performed with minimum interference in testing schedules. Standard switchgear has been used in the power circuits except in the output side of the testing generators where higher interrupting and short-time ratings are necessary. Specially designed equipment for this heavy service, however, was patterned after standard equipment.

The 13.8-kv switching equipment is standard vertical-lift metal-clad switchgear with 500-megavolt-ampere magneblast circuit breakers. The 480-volt switching equipment consists of two 1,000-kva double-ended load center substation units with drawout low-voltage air circuit breakers.

The connections from the generator terminals to the test cells and power transformers are made with isolated phase bus runs of conventional design but braced for 400,000 asymmetrical rms amperes.

The low-voltage connections on the secondary of the high-current transformers are interleaved to obtain maximum strength and minimum impedance.

Each generator backup circuit breaker and neutral circuit breaker is made up of three removable-type single-pole isolated-phase air-blast units, having primary and secondary disconnecting devices. See Figure 4. These are special adaptions of standard circuit breakers rated 14.4 kv, 3,500 megavolt-amperes interrupting rating, with momentary current rating of 270,000 amperes.

The synchronous closing switches are of the removable type and operated by pneumatically charged spring closing mechanisms. Since they are used for accurate closing duty only, the mechanism is arranged to obtain a short fast closing stroke that is consistently the same with respect to time for each operation. One of the horizontal rotating switches used to select the five taps of the high-voltage winding of the power transformer is shown on the cover.

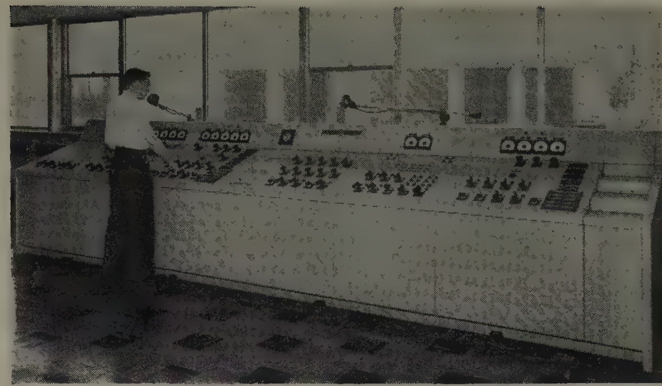


**Figure 3. Master control benchboard overlooking test area from control building**

## APPARATUS

APPARATUS WAS designed to provide testing facilities for all ratings of short-circuit interrupters now being produced and that may be required in the foreseeable future. This meant many incremental voltage steps up to 440 kv combined with incremental current values of high magnitude in either single-phase or 3-phase connections. The large testing generators, see Figure 5, with adjustable voltage and frequency control are used in conjunction with step-down transformers for high-current testing and with step-up transformers as shown in Figure 6 for high-voltage testing. Current-limiting reactors with several selectable taps for connection in the generator leads are used to provide incremental current values under short-circuit conditions. The electric connections are illustrated in the 1-line diagram, Figure 2.

A laboratory of this type with its large generating and conversion apparatus differs greatly from other types of testing laboratories or generating plants. Here the generator is deliberately short-circuited and its output is used solely to produce high values of low-power-factor current with transient characteristics duplicating or exceeding in severity those encountered in power transmission,

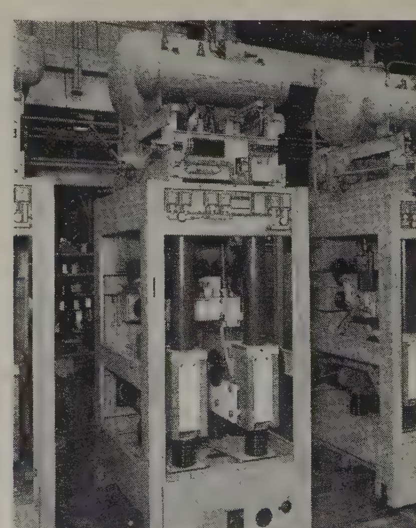


**Figure 4. Isolated phase backup and neutral air-blast circuit breakers shown during assembly**

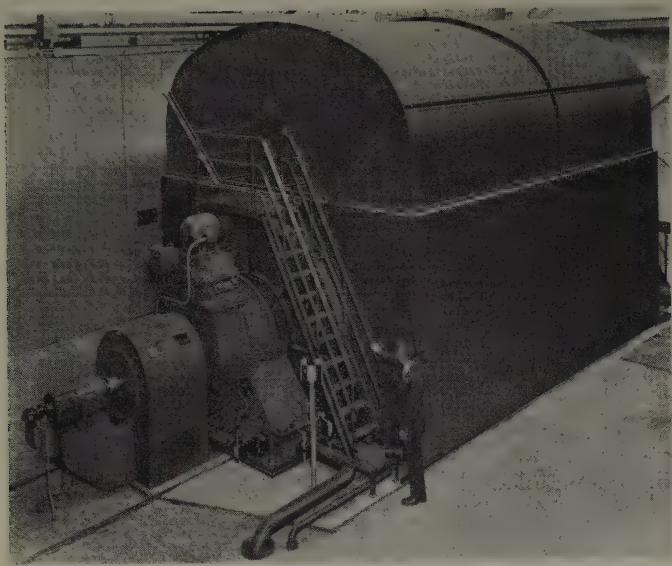


**Figure 5. One of the 15.5-kv 3-phase testing generators shown during installation**

distribution, and utilization circuits. For this reason special designs of generators, transformers, and connections were created to obtain the greatest short-circuit output with an unusually slow decrement. Nominal or continuous ratings are significant only as convenient references for design constants.

It was not feasible to build a single generator of sufficient capacity and physical size to deliver the maximum value of short-circuit current desired for this testing laboratory. However, it was possible to provide this capacity with two generators of practical physical size for operation in parallel. Also, since full station capacity is not required for the majority of the tests, the presence of two units has the additional advantage of doubling the testing facilities for most of the tests.

A larger number of units than two would have greatly increased the paralleling, switching, and control complications, and so two generators were provided, each nominally rated 125,000 kva, 3 phase, wound for 15,500/7,750/8,950/-4,475 Y or delta. On a 3-phase short circuit at 15.5 kv at the test cell location, 61,000 amperes or 1,600,000 kva symmetrical and 100,000 amperes or 2,700,000 kva asymmetrical (fully offset) can be obtained from each machine at 1/4 cycle after short circuit is applied.

The a-c component, considering its value at the end of the first 1/4 cycle as 100 per cent, is 81 per cent at the end of the first 2.5 cycles, and is 75 per cent at the end of the first 5 cycles. This eliminates the need for overexcitation prior to short circuit.

Each testing generator is driven by a 4,160-volt 3,000-horsepower wound-rotor induction motor equipped with automatic starting controls and liquid rheostats in the secondaries to provide stepless control of speed down to 8 cycles. Dynamic braking is used to stop the machine within approximately 15 minutes, which cuts down the long coasting time inherent in machines of this size. Equalization of rotor shaft cooling is obtained with a turning gear and motor.

The pilot generator is a 3-phase generator, directly connected to the main generator and synchronized in phase with it. Its purpose is to supply control power for actuating the tripping controls of the synchronous switches and for driving the sequence timers and oscillographs. This gives accurate synchronization of all these devices with the test voltage.

Multitap current-limiting reactors can be connected in each generator line to give 61 different current values for each 3-phase voltage connection. These, in conjunction with loading reactors when required, provide current values as low as 4 amperes at 15.5 kv for proving interrupting performance on extremely low values of load switching.

For low-voltage and high-current tests, three single-phase transformers are installed, each rated 24,000 kva continuous, 13,800 volts primary, 300/600/1,200 volts secondary, 240,000 kva short-time (5 seconds), and 5.85 per cent reactance.

The transformers can be connected in Y or delta or all in parallel for single phase. The bus-bar connections from the secondaries to the adjacent test cell are interleaved and firmly braced to give rigidity and low impedance.

For high-voltage testing, single-phase transformers are used each rated 100,000 kva, 7,750/15,500 volts primary, 38/72.5/84/140/220 kv secondary, and 2.99 to 7.6 per cent reactance. These transformers are arranged to be connected in parallel for single-phase high-capacity tests, in open-delta (2) and in Y (3) for 3-phase tests, in series for 440-kv tests, and as autotransformers for intermediate-voltage steps.

The high-voltage test yard includes two banks of 10,800-kva capacitors which can be connected in numerous series and parallel combinations. These are for the testing of interrupters used in the switching of transmission and subtransmission lines and for capacitor switching. These will simulate line-charging currents up to 200 miles of 230-kv transmission lines.

Each test car is equipped with primary disconnecting devices to which all power connections are made during the shop assembly setup. Floor rails in the cells and flanged wheels on the car guide the test car to engage the

**Figure 6. One of the high-voltage step-up transformers shown during installation**

disconnecting devices. With these facilities, power connections are made in minimum time so that test cells and testing apparatus are tied up for the least amount of time.

## TEST METHODS, CONTROL, AND INSTRUMENTATION FEATURES

The methods of conducting tests are essentially those which have been found to be most efficient during 30 years of experience in testing circuit interrupters. After all safety precautions have been taken, the prime consideration is to make the facilities available for continuous usage and to avoid idle generator time during preparation and dismantling of the apparatus under test.

The test circuit setup is made on the switchboard and with the aid of a mimic bus diagram, indicating lights and control switches, the entire power supply connections to the testing setup can be visualized.

Most tests can be accomplished without paralleling the generators so that normally one of the generators will be associated with one of the three test areas. By judicious allocation of cells, areas, and setups, testing can be carried out simultaneously for each of the two generators.

The apparatus to be tested is first assembled on a test car in the assembly room. A complete check is made there to determine that the apparatus is in proper operating condition. All primary power and secondary control connections are made to disconnecting devices permanently fixed on the test car. The car, Figure 7, is then moved by a battery-operated truck to the test cell where the disconnecting devices are automatically engaged to complete power connections to the de-energized generator power bus. Control connections are completed through a plug board in the test cell to the control building. Measuring apparatus, such as magnetic oscillograph shunts, voltage dividers for the cathode-ray oscillographs, and potential transformers, is permanently installed at each of the two groups of cells with their secondary connections made to

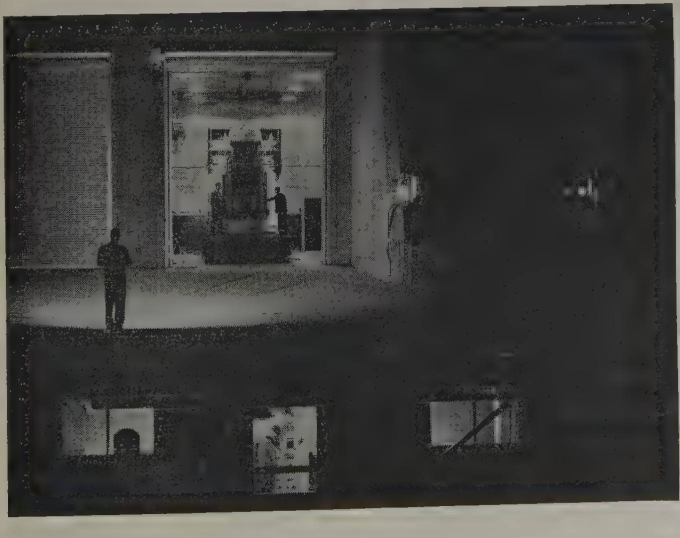


**Figure 7. Test car with large circuit breaker being inspected before a night short-circuit test. Observer in shockproof dugout, foreground, is ready to watch test at close range. Signal lights, right background, flash "red" warning test ready to begin**

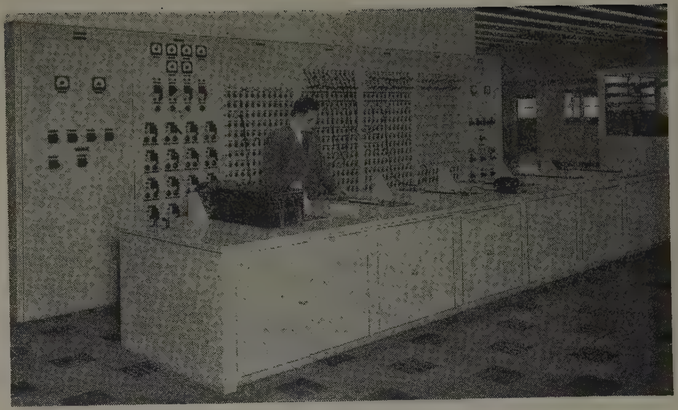


**Figure 8. Magnetic oscillograph table and plug board located in control building**

the oscillograph plug board in the control building. In this manner the test cell is tied up with a given apparatus for minimum time, and test power is required only during the time tests are actually being conducted.

All measuring apparatus circuits terminate in the control building magnetic oscillograph table and plug board, Figure 8, with the exception of the cathode-ray oscillographs which are located in the main building in the immediate vicinity of the test cells so as to have a minimum length of lead. Control of the generators and the apparatus under test is centered in a control benchboard located so that the operator has an unobstructed view of the entire area. By duplication of control and instrumentation circuits with transfer facilities, a complete setup can be made, checked, and a "dry run" made while the power apparatus is being used for other tests.

With the exception of repeated operations for life tests or multiple reclosing duty cycles, nearly all test shots are completed in a very short time with results measured in cycles or fractions of cycles. In this time, several closely timed mechanical operations may be performed with co-ordinated photographic high-speed recordings of measured quantities. Automatic sequence timers with multiple circuits and time interval adjustments in cycles and fractions of cycles are used for the purpose.

High-speed photographic instruments are used for the purpose of accurate measurement and visual representation of transient factors during testing, consisting of 3-element cathode-ray oscillographs recording transients such as recovery-voltage oscillation, 11-element magnetic oscillographs for recording cycles and magnitude of current, voltage, energy, and so on, electromagnetic pressure detectors for recording air or oil pressure, low-inertia travel indicators for recording mechanical motion.

A test is of little value if it cannot be expressed in accurately measured and documented data. The laboratory maintains adequate calibrating facilities that are periodically checked with company and national standards. Fast developing facilities and air-tube deliveries from the cathode-ray oscillograph room make the records available for analysis within 2 minutes. The records are completely documented for reference purposes and later stored in fireproof vaults.

## SAFETY FEATURES

When properly safeguarded, the hazards incident to high-capacity testing are no greater than will be found in a modern generating station, even though some apparatus may be tested to destruction, and dangerous test voltages are applied to temporary assemblies.

All permanently located apparatus is metal-enclosed to guard against accidental contacts and unauthorized access to live parts. Apparatus requiring maintenance, such as the power circuit breakers, is removable and automatic metal shutters close off the conductor entrances. This form of protection is a standard arrangement that will be found in high-capacity modern switchgear equipment.

Safeguards are also provided to prevent improper switching and application of voltage during the setup or preparation for test. Each piece of apparatus and its open or closed position is visually indicated on the setup switchboard permitting responsible checking before voltage is applied. In addition, the test areas are equipped with an illuminated test setup indicator board, warning lights, audible alarms, and access gate interlocks, all of which must be functioning before voltage is applied.

As a further safeguard to personnel, all tests are conducted within full view of the control operator whose responsibility is to determine that the area is clear before applying the power. The side of the control building toward the test area is provided with shatterproof windows for safe observation. Where a closer observation is desired, reinforced concrete observation booths, partially below ground level with bulletproof glass, are located between the control building and the test cells Figure 7. Two-way communicatinn keeps all areas in close contact.

## SUMMARY

The high-capacity development laboratory is a necessary adjunct to the engineering and manufacturing facilities of the General Electric switchgear operations. It will be used primarily for circuit interrupter development and is supplemented by other testing facilities at the switchgear factory. It is already well equipped to perform 60-cycle high potential tests, impulse tests, life tests, heat runs, temperature tests, quality control, as well as other tests and checks for development and production purposes.

The construction and placing in operation of this modern high-capacity developmental facility should give added confidence to the power industry that it can plan its rapidly expanding systems knowing that the manufacturers will be ready to meet its new requirements.

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# Linear Circuit Theory and Servomechanism Design


HOWARD HAMER



**The need for communication between design engineers and those engaged in research on feedback control systems has been felt by many people. This article stresses this as well as the problems faced by and the limitations imposed on design engineers.**


During the past decade, much work has been done in adapting linear circuit theory to servomechanism synthesis. This synthesis problem can be stated broadly as that of determining a network configuration to produce a particular kind of output for a given input, where the output might or might not be the same type of physical quantity as the input. In most servo problems, the input is a form of electric signal, the output is a mechanical displacement, and the required relation between input and output is one of proportionality to within a given error. The distinguishing mark of a servomechanism, in contrast to other electromechanical systems, is the use of feedback to increase accuracy.

The theory which has been found most useful for this work has been, quite naturally, that of feedback amplifiers, which started, for practical purposes, with the work of Nyquist[1] aud was carried through by Bode.[2] Development was very rapid during the early 1940's and in 1948 Brown and Campbell of Massachusetts Institute of Technology


Full text of paper recommended for publication by the AIEE Committee on Feedback Control Systems.



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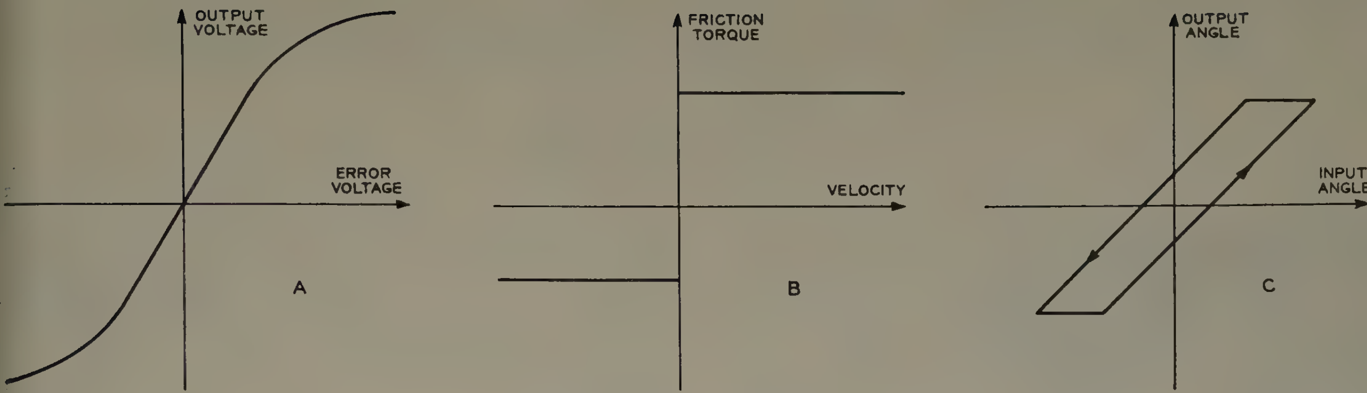


**Figure 1. Typical nonlinearities**

*A—Typical amplifier characteristic* *B—Typical friction characteristic* *C—Typical gear characteristic*

published a text[3] which just about brought the problem of synthesis of linear servomechanisms to a complete solution. The basic theory used was that of Bode, but equations and techniques were modified to facilitate rapid design of various types of systems. During the period from the appearance of the Brown and Campbell text until the present, much theoretical work has been done in linear servomechanism design, the purpose of which apparently has been to improve the quality of the finished design, and to speed up the design process. Of particular note in these respects were the introduction of the mean-square error criterion, and many graphical and analytic methods for detection of, and compensation for, instability. However, very little new was added to the theory, as most of the results were additional modifications of feedback amplifier theory still subject to the linearity restriction. (An exception must be noted in the work of Kochenburger[4] who analyzed a nonlinear system in a novel and very useful way. His solution to the relay servomechanism problem is, however, very limited in its application, and apparently offers little to those who are seeking a general solution which would not be limited to linear systems.)

The closest we have come to a general synthesis for the nonlinear servomechanism seems to be a technique which relies on a linearization of the system to obtain a first approximation to the final design, with either calculated or experimental modification to this design to obtain the final design. This method relies greatly on the experience and intuition of the designer, and its success seems to bear a direct proportion to the amount of time spent in making the modifications. In fact, many designers have given up entirely on the linear theory, and rely on modification of existing systems, determined in the laboratory by experimentation with the actual system, to produce the final design. The analogue computer has replaced the slide rule in many servo departments.

## LIMITATIONS OF TECHNIQUES BASED ON LINEAR CIRCUIT ANALYSIS

The linearity requirement can be stated, very roughly, as a requirement that the relation between the input and output of an element be independent of the amplitudes of both input and output. Therefore, very few servomechanism components are linear. Nonlinearities which are of particular importance in servomechanisms are

1. Saturation (Figure 1*A*).
2. Discontinuities (Figure 1*B*).
3. Hysteresis (Figure 1*C*).

These nonlinearities become important whenever an attempt is made to design a high-performance system. A high-performance system is usually considered to mean one which has very tight accuracy specifications and/or very wide bandwidth (fast response). Invariably in the design of such a system, one or more of these nonlinear effects is the limiting factor in the design. Straightforward analysis and synthesis by the use of conventional techniques does not offer any means of predicting these limiting effects and usually if a linear synthesis is carried out without any modifications to the process, the resultant system, which meets the designer's specifications, fails upon construction.

## SUMMARY

Servomechanism designers sometimes look with envy upon their fellow engineers who are engaged in the design of purely electronic systems, because the state of the art is such that a good paper design of a vacuum-tube circuit has a good chance of working properly the first time it is put together. (Computer amplifiers must be excepted, because the extreme feedback used puts a strain on both the amplifier and the designer.) What the designer needs, then, is a synthesis which will save him many of the hours spent in the laboratory searching for the right combination. He needs a better correlation between elementary servo design techniques and the actual performance of physical equipment. He needs special techniques to handle unusually nonlinear systems. And, above all, he needs closer liaison between those who do the research and those who build the products.

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# Nondestructive Tests for Generator Insulation

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COMPARISON OF nondestructive and destructive tests on old a-c generators before rewind, new generators, and coil specimens has brought fresh hope for the nondestructive evaluation of machine insulation. Results apply to mica-shellac insulation; other types are now under study.

The chief lesson learned was that nondestructive tests gain significance as voltage is pressed higher.

Insulation resistances between armature windings and ground were measured at increasing direct voltages by readings of the steady-conduction current after absorption effects had died away. It was found that the curve of insulation resistance against voltage was smooth, right through the point of breakdown. After eliminating one failure, a new curve could be obtained leading to a higher one, and so on. Therefore, once such a curve is carried to a voltage high enough to show a definite trend, it can be extrapolated to forecast the d-c breakdown voltage of the weakest point in the insulation under test. See Figure 1.

Curves are reproducible and readings remain stable to more than 90 per cent of breakdown voltage, showing the test to be nondestructive.

In a 2.3-kv generator there were some unpredicted breakdowns and also partial breakdowns in charred end-turn taping, but no such difficulties have been experienced with machines 6.6 kv and over.

Destructive tests supported the view that the ratio of direct to rms alternating breakdown voltages ranges from 1.41 for dangerous incipient faults to 2.4 for compacted slot insulation in sound condition.[1]

Absorption and discharge current-time curves were obtained at various direct voltages and temperatures and were integrated to give quantities of electricity. See Figure 2. It was found that the quantities absorbed and discharged were directly proportional to voltage right up to the imminence of breakdown. A specific figure,

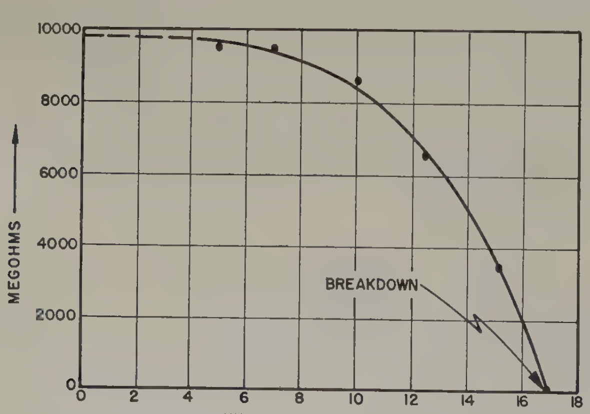


**Figure 1. Insulation resistance-voltage curve forecasts breakdown in 6.6-kv generator**

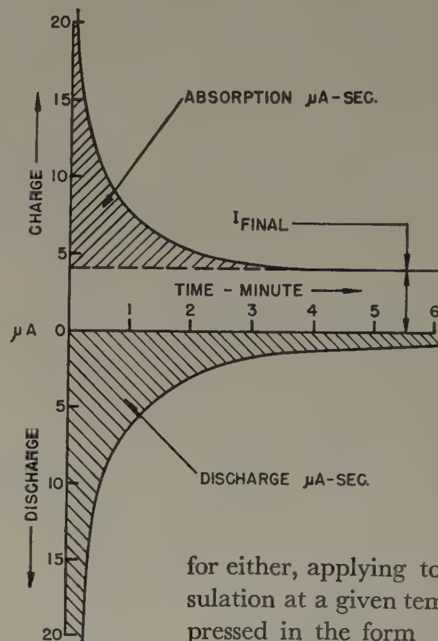


**Figure 2. Typical dielectric absorption and discharge curves**

for either, applying to a given body of insulation at a given temperature, can be expressed in the form

$$\frac{\text{Microampere—seconds}}{\text{Square feet stressed} \times \text{stress in volts/mil}}$$

On this basis, the specific absorption at 25 degrees centigrade was found to vary between 0.048 for a new mica-shellac-insulated stator just dried out and 0.003 for a 40-year old mica-shellac-insulated stator in very dry and brittle condition. A figure for mica-shellac insulation with sufficient flexibility remaining to withstand careful repair work was 0.024. This promises a nondestructive criterion for degree of embrittlement.

Good results were obtained by the use of power-factor–voltage testing for general severity of ionization at service alternating voltage, and of probing for areas of ionization, according to the methods of Povey and Oliver.[2] It was found that hazardous conditions of interturn and interstrand insulation generally were associated with voids, which by ionizing under stress showed clearly on the probe test.

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Digest of paper **52-59**, "Diagnoses of A-C Generator Insulation Condition by Nondestructive Tests," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The author desires to acknowledge the facilities for testing and co-operation afforded by the companies collaborating in the project described, and also the assistance in work and thought given by his associates in The Hydro-Electric Power Commission of Ontario, particularly, C. F. Book, G. W. N. Fitzgerald, K. B. Burns, and J. C. Cowdrey.

# Improvements in Transformer-Loss Compensators

G. B. SCHLEICHER
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TRANSFORMER-LOSS COMPENSATORS serve for the measurement of energy and demand as of the high-voltage side of power transformer banks with metering equipment located entirely on the low-voltage side. Advantages of their use are: generally lower costs;[1] savings in space; less exposure to lightning and other disturbances; and the conservation of critical materials. The basic compensator[2] comprises copper-loss and iron-loss elements that cause the meter to include these losses in its registration.

Extensive tests were made to permit the extension of use of transformer-loss compensators also for the higher values of losses incidental to var compensation, and the same solution was found to improve also the inductive load performance for watt-hour meters. By neutralizing the flow of the meter potential circuit current through the copper-loss compensator, its output voltage is proportional only to line current, instead of to line current plus potential current. It then is possible to reduce the full-load secondary current of the copper-loss transformer from 0.5 ampere to 0.25 ampere which results in a desirable reduction of current-circuit burden.

The potential circuit current compensation consists of a capacitor connected to a voltage in phase with the supply voltage, and a resistor connected to a voltage displaced 180 degrees from the supply voltage. The resultant current of the capacitor and resistor is adjusted to be equal and opposite to the meter potential coil current, so that the resultant extraneous current through the copper-loss compensator is zero. The potential circuit burden is sufficiently low so that a compensator and a watt-hour meter potential coil may be connected to a standard var autotransformer.

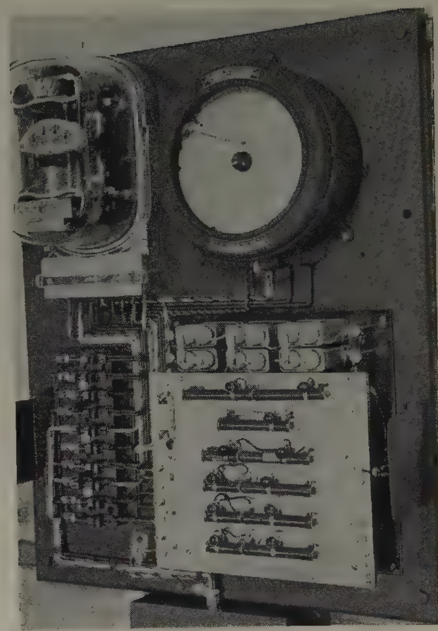

**Figure 1. Typical 3-element meter panel with transformer-loss compensator on a 2.3/4.0-kv 1,500-kva installation compensated to the 33-kv supply, panel cover removed**

**Table I. Summary of Test Results in Terms of Per-Cent Deviation From Desired Values of Load Plus Copper Loss**

*Tests Made at 120 Volts With Type-IB-10 Portable Standard Watt-Hour Meters*

| Load | | Desired Loss, Per Cent | Per-Cent Deviation | | |
|---|---|---|---|---|---|
| | | | Potential Circuit Compensation | | |
| Amperes | Power Factor | | None | Capacitor | Complete |
| 1.0 Per Cent Copper Loss at Meter Rating | | | | | |
| 7.5 | 1.0 | 1.50 | +0.11 | +0.11 | 0 |
| 5.0 | 1.0 | 1.00 | 0* | 0* | 0* |
| 2.5 | 1.0 | 0.50 | −0.02 | 0 | +0.05 |
| 0.5 | 1.0 | 0.10 | −0.06 | +0.01 | +0.05 |
| 7.5 | 0.5 | 3.00 | −0.73 | +0.37 | 0 |
| 5.0 | 0.5 | 2.00 | −0.33 | +0.24 | +0.06 |
| 2.5 | 0.5 | 1.00 | −1.09 | +0.09 | +0.06 |
| 0.5 | 0.5 | 0.20 | −1.18 | −0.09 | +0.01 |
| 5.0 Per Cent Copper Loss at Meter Rating | | | | | |
| 7.5 | 1.0 | 7.50 | −0.30 | 0 | −0.14 |
| 5.0 | 1.0 | 5.00 | 0* | 0* | 0* |
| 2.5 | 1.0 | 2.50 | −0.27 | −0.05 | 0 |
| 0.5 | 1.0 | 0.50 | −0.39 | −0.05 | −0.07 |
| 7.5 | 0.5 | 15.00 | −4.67 | +1.25 | +0.10 |
| 5.0 | 0.5 | 10.00 | −4.37 | +1.73 | +0.10 |
| 2.5 | 0.5 | 5.00 | −5.05 | +0.13 | −0.07 |
| 0.5 | 0.5 | 1.00 | −1.18 | −0.27 | +0.03 |

* Point of adjustment of copper-loss compensation.

Table I shows test results in terms of per-cent deviation from desired values of load plus copper loss for loss values of 1.0 per cent and 5.0 per cent at the meter rating. Comparative values are given; without potential circuit compensation, with capacitor compensation only, and with complete compensation for the meter potential circuit current. The results with complete compensation are considered satisfactory.

Figure 1 shows a service installation of a 3-element watt-hour meter with a transformer-loss compensator. The metering equipment is connected to the low-voltage side of a 1,500-kva 33:2.3/4.0-kv transformer bank, and measures energy and demand as of the high-voltage supply side.

The transformer-loss compensator provides a companion method to high-voltage metering. Its use frequently results in economies, and with potential circuit current compensation of the copper-loss elements, both watt-hour and var-hour compensation can be provided throughout the range of iron and copper losses.

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# High-Temperature Dry-Type Transformer Economics

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THE ADVENT OF high-temperature insulations, such as silicones, has moved upward the possible design limit due to deterioration of insulation with temperature. Formerly, the transformer designer used insulation to the temperature limit dictated by its aging characteristics and a reasonable life. The point is now reached, however, at which other factors should be considered. Higher temperatures may cause large variations of electrical characteristics as the load is varied and also cost of losses may overbalance savings in initial cost, and the decrease in size and weight.

Technical limitations such as increased insulation aging, hot spot temperatures, and transformer vault cooling, as well as decreases in overloadability, and possible crystallization of the copper wire, all have an important bearing on the final practical high-temperature transformer. This analysis will, however, treat only the maximum possible reduction in first cost, and secondly, the modification of this cost by such items as transformer losses and regulation.

The basis for this investigation is a series of dry-type transformer designs made in the 1,000-kva 13.2-kv size, maintaining the transformer impedance but reducing the copper in the windings and hence increasing rated temperature rises and also the copper losses. These higher temperature designs thus have a lesser first cost due to reduction of material. They do, however, have considerably greater losses and increased regulation. These latter items thus modify this lower first cost and make such transformers less attractive than might be expected.

**Table I. An Evaluation of Possible Typical Cases**

| Possible Typical Capitalization | | Open Units | | | | Sealed Units | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Class B | | Class H | | Class B | | Class H | |
| Copper Loss, $/kw | Regulation Loss, $/kw | Optimum Rise, Degrees Centigrade | Possible Savings, Per Cent | Optimum Rise, Degrees Centigrade | Possible Savings, Per Cent | Optimum Rise, Degrees Centigrade | Possible Savings, Per Cent | Optimum Rise, Degrees Centigrade | Possible Savings, Per Cent |
| Average all utilities 150 | 85 | 75 | 0 | 95 | −10.5 | 155 | 1.5 | 185 | 5.0 |
| Industrial users 310 | 0 | 75 | 0 | 95 | −15* | 150 | 1.3 | 183 | 5.4 |
| Networks 50 | 60 | 95 | 2.0 | 115 | − 6.5 | 200 | 5.5 | 230 | 9.5 |
| Station auxiliaries 150 | 0 | 95 | 2.8 | 120 | − 7.1 | 200 | 6.1 | 227 | 10.9 |

* Approximately

Note 1: Open unit savings based on 70-degree-centigrade-rise units = 100 per cent
Sealed unit savings based on 120-degree-centigrade-rise units = 100 per cent

Note 2: All rises are average rise by resistance

The transformer losses and the loss of revenue or efficiency due to regulation may be capitalized and added to the first cost, and from the range of user costs which results, a minimum total user cost determined. The most economical design, and hence the most economical temperature, thus depends upon the particular values assigned to the capitalization of losses and regulation.

A series of graphs shows how the variation in per cent possible savings, and corresponding optimum temperature rise at full load, depends upon capitalization of copper loss and regulation loss. These include both open and sealed units with either Class *B* or Class *H* insulation.

Using the graphs and possible typical capitalizations of copper loss and capitalization of loss of revenue due to regulation, for various cases of transformer application, the results shown in Table I are obtained. If desired, other capitalizations can be used to see the possible variations; but it is believed that those shown are fairly representative.

The following may be concluded:

1. The possible savings at the present time to the user of open dry-type transformer, designed for higher temperature rises than are presently used, are small, being less than 3 per cent in the most favorable cases.

2. The optimum temperature rise of the open dry-type transformer at the present time is in most cases very close to the rises presently used. In such cases as station auxiliary transformers and network transformers of this type, a temperature rise of approximately 95 degrees centigrade is indicated as most economical for the specified conditions, assuming materials are available for operation at these higher temperatures with normal life.

3. In all cases the Class *H* open dry-type transformer has a user cost of the order of 10 per cent more than the corresponding Class *B* open dry-type transformer.

4. Possible savings to the user of the sealed dry-type transformer, designed for higher temperature rises than presently are used, may be in the range of 1 to 10 per cent.

5. The optimum temperature rise to achieve the savings of any magnitude under conclusion 4 are in the range of 180 to 230 degrees centigrade with probable hot spot temperatures of 240 to 300 degrees centigrade. These temperature rises have not been demonstrated as realizable at the present time due to technical limitations outlined in the early part of this article.

6. User publication of up-to-date data on the range of capitalized losses applicable to different types of transformer installations will greatly assist manufacturers in the selection and standardization of designs having the most economic temperature rise.

Digest of paper 52-89, "The Economics of High-Temperature Dry-Type Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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# The ABC's of Germanium

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**Germanium is one of the most important elemental semiconductors. Some of the mechanisms governing its behavior are here presented in a simplified manner as background for the understanding of the physics of the industrial devices utilizing it.**

THE FIELD OF the semiconductors embraces that broad category of solid materials whose characteristics lie between those of the conductors and the insulators. The mechanisms governing their behavior are not well known. They can be broadly divided into two categories, the compounds and the elements. Among the elemental semiconductors exhibiting rectifying properties are silicon, gray tin, and germanium. Of these, germanium has been studied most intensively because its physical properties are best suited for industrial application, although silicon crystals were in use long before the rectifying properties of germanium were recognized. Thus, the following discussion presents, in engineering language but in a simplified manner, some of the mechanisms governing the behavior of germanium. However, it must be understood that because of the complexity of the subject and the lack of understanding of many of the phenomena, the explanations given are, in many cases, not rigorous and in the light of future developments may even be erroneous. However, they provide a working understanding of the behavior and limitations of germanium as applied to industrial devices, and permit following future developments of the devices with some comprehension.

Germanium is a hard, silver-gray metal with a very high mechanical Q, that is, an undamped bar will ring for many seconds when struck. It is extremely brittle, fracturing very easily if struck, and cannot be bent or mechanically worked. Its density is approximately $5^1/_2$ grams per cubic centimeter or about two-thirds that of iron. It appears to be nontoxic. The melting point is not well known, there being some five reliable reports in the literature placing it variously from 927 to 968 degrees centigrade. The cause of this discrepancy is not known. In the periodic table, it is in the fourth group, thus having four valence electrons in the outer shell. It crystallizes in the same cubic pattern as the diamond. This is the most complex of the cubic structures; it can best be visualized by picturing two face-centered cubes interpenetrated so that the corner of one lies in the 1/4–1/4–1/4 position with relation to the other.

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## PRODUCTION AND PURIFICATION

GERMANIUM IS widely distributed in nature, being found in trace quantities in many minerals. The primary source in the United States, however, is from the stack residues of the zinc smelting industry, the Eagle-Picher Company being the sole processors of these residues at this time. However, many other companies report finding germanium in their stack residues either from zinc or from coal. Thus, there does not appear to be any immediate threat of a shortage of the element, although if its use expands tremendously it may be necessary to set up additional processing units.

The Eagle-Picher Company normally supplies germanium dioxide, a white powder which is reduced by the user to metallic germanium in a hydrogen furnace at approximately 650 degrees centigrade, after which it is melted in the same furnace to produce germanium ingots. In the General Electric Company, all metal is next put through a fractional crystallization purification process which involves melting the metal in a carbon boat in an inert atmosphere, and permitting it to cool from one end to the other at a rate of 1 to 8 inches per hour. This results in a segregation of the impurities such that those which have a greater solubility in the solid phase solidify out first, while those having a greater solubility in the liquid phase remain in the liquid and collect at the opposite end of the billet. If the material so obtained does not have sufficient purity, the ends can be broken off, several center sections combined, and the process repeated until the required purity is obtained. This process is approximately

90 per cent efficient, as it is necessary to discard approximately 10 per cent of the germanium containing the concentrated impurities.

Germanium is cut with diamond saws into small wafers usable in the various products. These saws are normally on the order of 0.020 to 0.025 inch thick, whereas the wafers vary from 0.015 to 0.025 inch depending upon end application; thus, a considerable quantity of the original germanium is lost as cutting sludge. This sludge, as well as the impure ends from the fractional crystallization purification process, can be reclaimed readily by reacting it with chlorine at approximately 300 degrees centigrade which gives germanium tetrachloride, a clear liquid similar in characteristics to carbon tetrachloride. This liquid then can be distilled in a fractionation column to remove the gross impurities. The pure tetrachloride then can be poured into ice water where it immediately hydrolizes to germanium dioxide. Several years ago, the total utilization of germanium in the General Electric Company was approximately 8 per cent, that is, approximately 92 per cent of the germanium was lost in processing to the final product. However, using these new techniques, nearly 90 per cent of the germanium is now utilized.

The material obtained from the fractional crystallization purification process is multicrystalline. For whisker contact devices, this material is quite usable since the crystallites are relatively large and the probability of striking a crystal boundary with the whisker is relatively small. However, for devices using the newer techniques, single crystals are necessary since any crystal interface appearing in a wafer makes it unusable. See Figure 1. Single crystals are generally produced by the Czochralski technique. Liquid germanium in a carbon crucible is held at a temperature a few degrees above the melting point, and single crystals are drawn from the melt by immersing the end of a single crystal seed and slowly withdrawing it. See Figure 2. The temperature of the melt and the speed of withdrawal determine the diameter of the crystal so produced. This process is carried out in an atmosphere of either hydrogen or an inert gas such as argon.

## CONDUCTION MECHANISMS

The electrical characteristics of germanium are greatly affected by amount and type of impurity present. Some impurity concentrations as small as one part in $10^{11}$ can readily be detected by electrical means. The three types of germanium in which we are interested are the *n*-type, *p*-type and intrinsic germanium. The mechanism of conduction involved in these three types must be understood (at least in a qualitative way) to permit a discussion of their rectifying action. In the germanium lattice, there are four valence electrons associated with each atom. See Figure 3*A*. This can be visualized as eight shared electron bonds connecting a germanium atom with its four nearest neighbors, four being supplied by the outer electron shell of the parent atom and one each being supplied from the outer shell of the four adjacent nearest neighbors. If, however, one of the atoms is an element from the fifth group of the periodic table having five valence electrons, only four of these electrons can be shared with the adjacent germanium atoms. See Figure 3*B*. The fifth electron is bound to the impurity atom only by the relatively small excess charge of the nucleus. The binding energy in this case will be very small since all surrounding germanium atoms are energetically satisfied

**Figure 2. Chamber of single crystal furnace showing liquid germanium bath and seed crystal attached to end of pulling rod**

and exert no force on the extra electrons. Such electrons can readily be broken loose to wander through the lattice, 3*C*. If a potential is applied, these electrons can travel relatively tremendous distances through the lattice, and thus contribute to conduction by directly carrying charge from one area to another. This, then, is known as *n*-type germanium, *n* standing for negative. The impurity element causing it is called a donor impurity since it donates an electron to the lattice and the conduction is by actual transport of charge by a single electron through the lattice.

If, however, the impurity atom referred to previously were from the third group of the periodic table, thus having only three valence electrons, it could satisfy only three of the four electron bonds required of it by the germanium lattice, thus leaving one bond unsatisfied. See Figure 3*D*. In this case, the energies present seeking to fill the unsatisfied bond are tremendous, being less than that present between two germanium atoms only by the slightly reduced charge on the impurity atom nucleus. Thus, only small amounts of external energy are required to cause an electron from an adjacent bond to jump into the unsatisfied

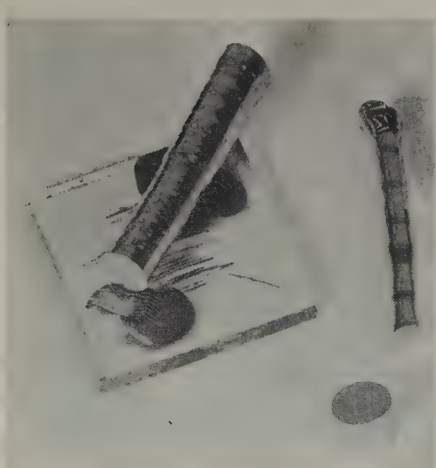

**Figure 1. Germanium crystals**

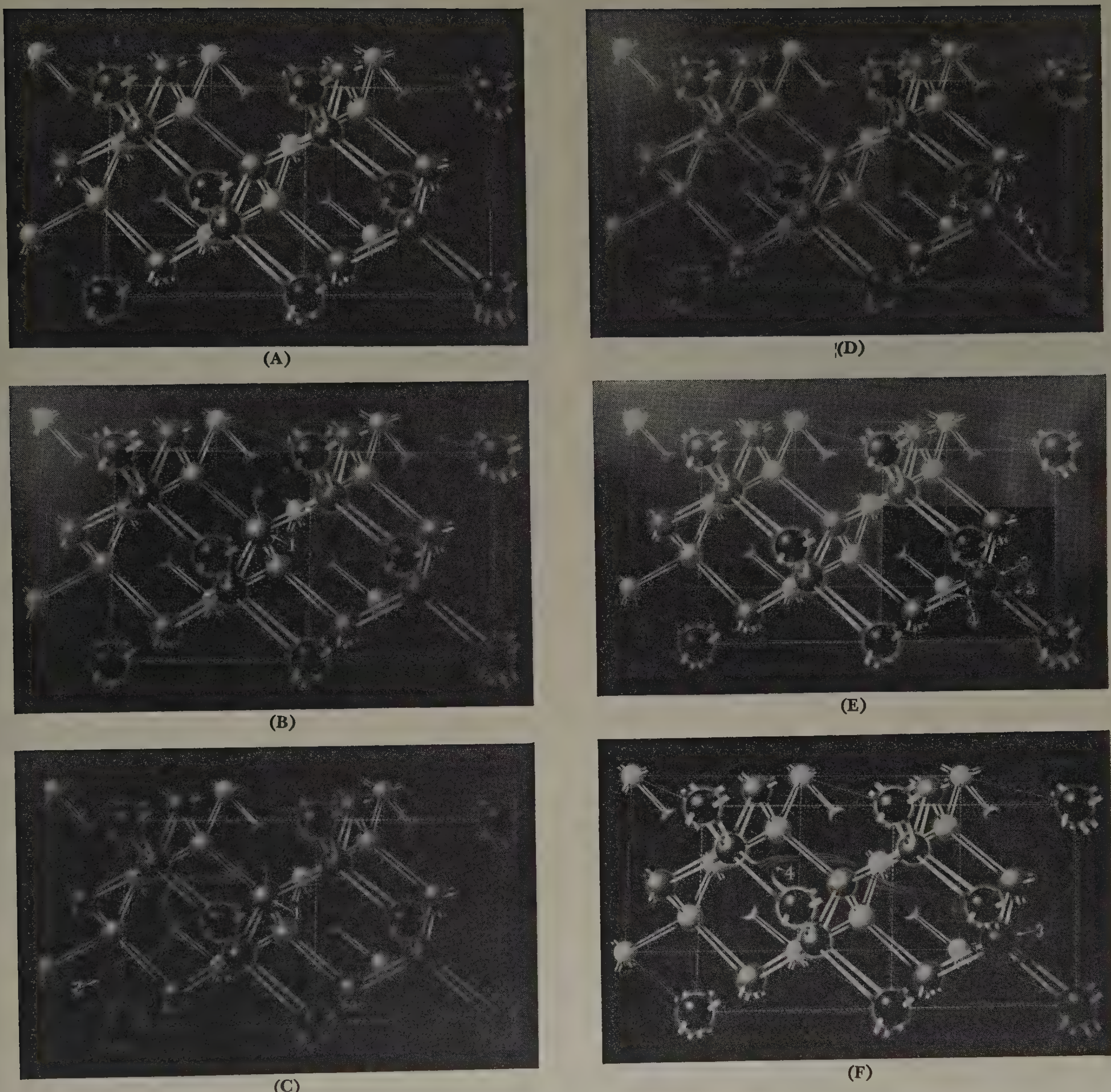


**Figure 3.** A—Schematic representation of germanium lattice showing shared electron bonds. B—Donor atom substituted in germanium lattice. Note loosely bound extra electron. C—N-type conduction. Electron broken loose from donor atom by thermal energy. D—Acceptor atom substituted in germanium lattice. Note unfilled bond. E—Filling vacant bond by thermal excitation of electron from nearby bond. F—P-type conduction. Hole migrating through lattice by excitation of electron from bond to bond

*1. Donor atom 2. Conduction electron 3. Acceptor atom 4. Hole 5. Trapped electron*

bond, thus leaving a new vacancy in the near vicinity. See Figure 3*E*. These vacancies are called holes and, in so far as electrical tests are concerned, cannot be distinguished from positive electrons with masses approximating that of the true electrons. If an electric field is applied across such a piece of germanium, the current will be carried by successive jumps of electrons from filled valence bonds to nearby vacant bonds, as shown in Figure 3*F*. The effect, therefore, is that of a migration of a positive charge through the lattice in the opposite direction to that of the electron movement. This, then, is *p*-type germanium, with *p* standing for positive. The impurity elements are called acceptor impurities since they are recipients for electrons, and the conduction phenomena involve a migration of holes, the transport involving small movements of a great many electrons.

If, however, the germanium has less than approximately one part in $10^{12}$ of donor and acceptor impurities or has a nearly equal number of donor and acceptor impurities so that the extra electrons from the donor impurities can fill the vacancies of the acceptor impurities, the material is called intrinsic and conduction must take place by

exciting electrons directly out of the valence bonds. Obviously, for every valence electron broken loose a hole is left behind. However, since conduction by electrons involves continuous movement of charge, while conduction by holes involves an intermittent slower migration of charge, the electron or $n$-type conduction always dominates. The resistivity of such germanium at room temperature is on the order of 60 ohm-centimeters. Since at higher temperatures the valence bonds are most easily broken and more electrons are thus excited to wander through the lattice, the high-temperature resistivity is lower than 60 ohm-centimeters while the inverse is true for low temperatures. This concept explains the negative temperature coefficient of resistance for germanium. Furthermore, since there are many more electrons tied up in germanium valence bonds than can be supplied by impurity atoms, at some temperature the carriers supplied by thermal excitation from the valence bonds will swamp those supplied by impurity atoms regardless of the purity of the germanium. For reasonably high purity germanium, this temperature is of the order of 100 degrees centigrade. This means that $p$-type conduction cannot exist as such above that temperature, and rectification cannot be realized.

The donor impurities include those fifth group elements having five electrons in the outer shell, such as phosphorus, arsenic, and antimony. The acceptor impurities include those third group elements having three electrons in the outer shell such as boron, aluminum, gallium, and indium. However, recent investigations throw considerable doubt on the validity of this picture. Neither thallium (third group) nor bismuth (fifth group) appears to be electrically active, although it has been postulated that because of their atomic size they cannot fit into the lattice. However, there are strong suspicions that zinc (second group), platinum (transition), and gold (first group) are acceptor impurities, while cadmium (second group) and manganese (seventh group) are donor impurities. These suspicions lead to two possibilities: Either this mechanism is correct for the third and fifth group impurity atoms listed and a new, still unknown, mechanism exists to explain the nonconforming impurities, or the entire picture is in error and must be replaced with some new mechanism which will be consistent with all phenomena observed.

The conduction characteristics of germanium can be modified by two additional means. Recent studies in this laboratory by the writer have indicated that localized pressures on the order of 200,000 pounds per square inch can permanently modify the conduction characteristics of very restricted areas from $n$-type to $p$-type. This modification is permanent and apparently stable with time. Whether this is due to microscopic fracturing of the lattice or to modification of the basic lattice by the compressive stress is not yet known. Likewise, if germanium is heated to a temperature above 500 degrees centigrade and then quenched, it will become $p$-type, this modification apparently being stable at room temperatures but capable of being restored to its initial $n$-type conduction by holding at a temperature below 500 degrees centigrade for an appropriate length of time and slow cooling. The times involved vary from 15 minutes to several hundred hours, depending on the initial impurity content and whether the sample was multiple or single crystal. Oddly enough, the single crystal, high purity material takes the longest time to return to its initial state. The various theories conceived to explain these phenomena are as yet too vague to warrant presentation here.

## MEASUREMENT TECHNIQUES

THE MEASUREMENT OF the characteristics of germanium has not yet been developed to the point where the usefulness of a specific sample can be completely determined. There are available four powerful techniques capable of measuring certain characteristics of germanium. These are: resistivity, Hall coefficient, thermoelectric power, and lifetime.

Resistivity measurement taken in the normal manner can be misleading if the sample is not single crystal, due to the fact that the crystal interfaces often form barriers which can seriously modify the observed resistivity. This difficulty can be overcome by using microresistivity techniques, or by confining such measurements to single crystals of the material. The resistivity so measured is related to the number and mobility of the particular type of carrier present. The relationship is $\rho=1/eNB$, where $N$ is the number of free carriers present, $B$ is the mobility of those carriers, and $e$ is the charge of an electron. Thus, it can be seen that the resistivity involves the product of the density of the excess carriers and their mobility.

The Hall effect can be observed when a current-carrying semiconductor is placed in a transverse magnetic field. This magnetic field distorts the current flow in the semiconductor thus creating a potential orthogonal to the direction of current flow and the magnetic field. In practice, this reading is taken by cutting a thin wafer whose $X$-direction is at least twice the $Y$-dimension, the $Z$-dimension being taken as the thickness of the wafer. Ohmic contacts are made along the short edge of the wafer and a current measured in milliamperes is passed between these contacts. A magnetic field on the order of thousands of gauss is applied in the $Z$-direction, and the potential developed is determined at point contacts located at the center of the long edges of the wafer. This potential is proportional to the magnetic induction and to the current density. The proportionality constant $R$ is the Hall coefficient. Thus, $R = E_y/J_x B_z$. In the case of $n$-type germanium, $R=-[3\pi(1)]/[8(eN)]$ where $N$ is the number of carriers available. Since the factor of $3\pi/8$ can be assumed unity within the accuracy of most measurements of this type, $R$ can be taken to equal $-1/eN$. In the case of the $p$-type semiconductor, the sign changes to plus and $N$ becomes the number of free holes available for conduction. Thus, the Hall coefficient gives us directly the number of free carriers available for conduction and, in combination with the resistivity, gives a value for their mobility. Furthermore, if we wish to assume that the number of carriers equals the excess number of impurity atoms, we also can determine from the Hall coefficient the number of impurity atoms present in the lattice.

The thermoelectric power also can be related to the

number of carriers, but because of the difficulty of obtaining accurate values for the constant, it is rarely used. However, one characteristic of the thermoelectric power makes it extremely valuable. This is that the sign changes when the type of carrier changes. Thus, if a piece of germanium is connected through a microammeter to a hot probe, and the probe is touched to the surface of the germanium, a positive or negative indication on the microammeter immediately determines the type of carrier present. It is subject to misinterpretation only when surface layers of the opposite type are sufficiently thick to permit existence of the major part of the temperature drop in their body. This can be eliminated by testing only freshly etched surfaces.

The mean lifetime of a carrier can be measured in several ways. Only the simplest and most direct method will be described here. Originally described by Valdes, it involves applying a small potential between the base of a wafer of germanium and a point contact on the top surface. This potential must be low enough to collect the carriers present between the contacts, but insufficient to excite any new carriers into conduction. A line of light is then permitted to fall on the surface normal to the point contact. This light beam will release additional carriers which will spread outward in all directions. These carriers which reach the immediate vicinity of the point contact will be collected and cause an increase in the current flow. If a curve is drawn of current increase versus distance from the light beam to the collector point, the slope of this curve can be interpreted in terms of the average lifetime of the type of carrier present. The factors affecting the lifetime of a carrier are not as yet well understood; however, it is known to be tremendously influenced by surface characteristics and cleanliness as well as by the bulk characteristics of the germanium.

A number of other measurement techniques have been and are being studied; however, at the present state of the art, either their interpretation is subject to considerable confusion, or the results obtained are so similar to the characteristics obtained by the techniques described herein that it does not appear to be necessary to describe them here. It should be recognized also that the simplified treatment given in the foregoing does not include many minor effects which may or may not affect the measurements given. While we can determine the number of carriers directly concerned in conduction, we do not yet have unequivocable means for determining either the total number of electrically active impurity atoms present or the number of nonelectrical impurities which could well affect some characteristics of the germanium.

## P-N JUNCTION THEORY

A RECTIFYING BARRIER exists in germanium when $p$- and $n$-areas are created adjacent to one another in the same continuous germanium lattice structure. This can be visualized by assuming a single crystal bar of germanium, one-half of which is $n$-type and the other half $p$-type. See Figure 4. With no potential applied, there are thermally excited electrons in the $n$-side and thermally excited holes in the $p$-side. It should be realized that, under this condition, the number of electrons or holes available is a statistical function of temperature, some carriers constantly being trapped by the impurity centers, while others are being excited into the lattice. Now, if a potential is applied in the back direction, that is with the positive polarity connected to the $n$-germanium, the electrons will be attracted to the positive connection and the holes to the negative connection. However, since there would be very few holes in the $n$-type germanium, or

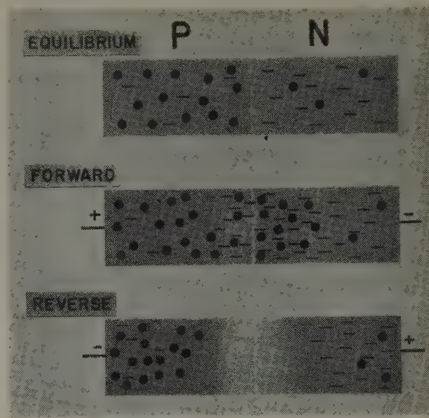


**Figure 4. Conduction mechanism in P-N junction**

free electrons in $p$-type germanium, little current can cross the barrier between the two types. The area between the $n$- and $p$-germanium will have very few carriers of either type since they would be attracted away from this zone. This zone is called the barrier layer and is essentially intrinsic in character. Its thickness depends largely upon the applied potential, becoming broader as the potential is increased, and varying from roughly $10^{-2}$ to $10^{-5}$ centimeter.

If, however, the potentials are reversed so that the negative potential is applied to the $n$-germanium and the positive potential applied to the $p$-germanium, the electrons and holes in the germanium are attracted toward each other. Naturally, when an electron and a hole meet, they cancel each other creating a normal valence structure. Under this condition, the electrons enter the $n$-germanium from the negative connection, progress through the $n$-germanium to the barrier where they are absorbed by combining with holes which were created in the germanium at the positive connection and progressed through the $p$-germanium in the opposite direction. Thus, the conduction mechanism in the $n$-germanium is by means of electrons, while in the $p$-germanium it is by means of holes. The barrier area now becomes a zone of recombination of holes and electrons. This condition is ideal for low resistance to current flow.

It should be noted that since the lattice dimensions are very large compared to the area or volume influenced by a hole or electron, many holes will penetrate the $n$-type germanium to a considerable distance before coming within the field of influence of an electron to permit recombination. Likewise, a number of electrons will penetrate the $p$-type germanium before recombination takes place. The depth to which this penetration occurs is determined

by the impurity concentration. Thus, if the density of holes in the *p*-type germanium far exceeds the density of electrons in the *n*-type germanium, many more holes will penetrate the *n*-type germanium than electrons in the *p*-type germanium. The importance of this concept will be realized later in the description of transistor action.

## RECTIFIERS

From the foregoing data, a possible mechanism for the operation of the various rectifying devices can be explained. To review, the techniques available for creating *p*-areas in *n*-germanium, or conversely, within the same lattice are pressure, which creates a *p*-area in *n*-germanium; heating and quenching, which will transform *n*-germanium into *p*-germanium; diffusion of an impurity metal of the opposite type into the lattice under the influence of heat; and doping of the melt while pulling a single crystal. The first two appear to be important in the whisker diode. Initial rectification of a relatively low order is observed when the whisker first makes contact with the surface of the germanium. This rectification could be due to the formation of *p*-germanium by pressure immediately under the contact. During the forming or pulsing operation to which all commercial diodes are subjected, temperatures as high as 900 degrees centigrade are known to exist in the whisker near the point of contact. Since only a very restricted area is heated in the short times used for pulsing, the cold surrounding body of germanium rapidly quenches the heated area, thus creating a small zone of *p*-germanium immediately surrounding the whisker contact. In addition, there may be some diffusion of the whisker material into the germanium.

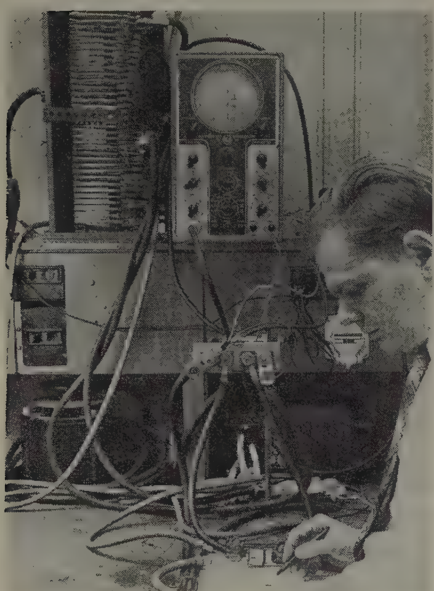

**Figure 5. Laboratory test setup for high-current diode. Note E-I characteristic on oscilloscope. Operator is pointing to a 1-square-centimeter rectifier wafer similar to that mounted in same holder**

The *p-n* junctions formed by diffusion or by single crystal doping can be made to have much greater barrier areas. Single crystal doping involves the use of a relatively high purity melt in the single crystal furnace described previously. Then, while pulling the crystal, the characteristics of the melt are abruptly changed by dropping into it a pellet containing a third- or fifth-group element depending on the type of germanium used initially. The quantity used is sufficient to cancel the effect of the initial impurity atoms and create enough of the opposite type to give the desired conduction characteristics. This process can be repeated to give a number of *n-p* barriers per crystal. This technique is being applied to diodes and transistors by Bell Telephone Laboratories.

The diffusion technique developed by the General Electric Company involves diffusion of a donor or acceptor metal into a wafer cut from a single crystal of the opposite type. This is done by placing the impurity element on the clean germanium surface and heating the assembly until sufficient alloying and diffusion has taken place. This permits location of the barrier (or barriers) wherever desired and controlling the area of the barrier by the amount of impurity metal used.

Diffused solid contact devices have been made by the General Electric Company exhibiting peak inverse voltages as high as 1,000 volts and forward current capacities as high as 700 to 800 amperes per square centimeter peak. Since the areas which can be covered by such a diffused junction are limited only by the perfection of assembly techniques, high-current devices can be expected. See Figure 5. A number of such devices have been made in the laboratory covering approximately 1 square centimeter, which have readily carried the currents as high as the 700-ampere peak with peak inverses as high as 350 volts. A commercial product recently was announced by the General Electric Company which utilizes a somewhat smaller area of contact which is rated at 200 volts peak inverse at approximately 1/2 ampere average forward current. See Figure 6. For these devices, the forward resistance is on the order of 1 ohm, while the back resistance varies from 500,000 ohms to 5 megohms. Many other modifications of these devices using such techniques can be expected in the future.

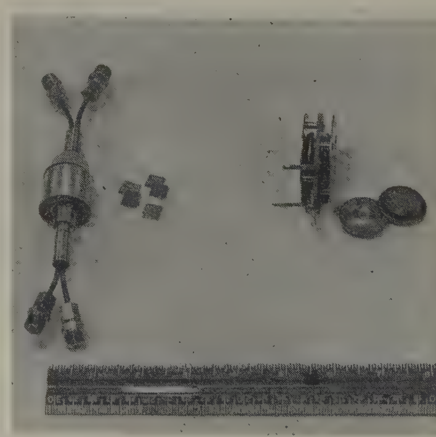

**Figure 6. Germanium P-N junction diodes. Commercial G-10 units on right, developmental high-current wafers and water-cooled case on left**

## TRANSISTORS

In the operation of the transistor, the diffusion of carriers of the opposite type through the germanium is utilized. If we picture two areas of *p*-germanium separated by a thin zone of *n*-germanium with ohmic contacts made to all three areas, current flow can be maintained

in the forward direction from either of the $p$-areas to the $n$-connection or base connection. If, however, we connect these three areas such that forward current is initiated from one $p$-area, called the emitter electrode, to the $n$-area or base while the remaining $p$-area, called the collector contact, is biased in the back direction, it is found that the majority of the current flow exists between the emitter and collector due to the great number of holes from the $p$-area which diffuse through the thin $n$-zone into the $p$-collector zone without recombining with the electrons in the $n$-zone. When the base potential is increased, more carriers are pulled from the emitter zone and, thus, more are available for diffusion to the collector zone. Those carriers which do not reach the collector combine with carriers of the opposite type and contribute to the base current, thus reducing the "gain" of the device. To reduce this loss of carriers, the $n$-zone is kept as thin as possible and the carrier content reduced by using high-purity material. This results in a 3-element control device with rather remarkable characteristics which have been described in detail in a number of recent papers. They can be made using any of the techniques described.

In the case of the whisker transistors, actual carrier multiplication has been observed. Although not well understood as yet, this could be due to the formation of an $n$-$p$-$n$ region at the collector contact by diffusion of the whisker material as explained. Such devices have a much higher noise level and more limited power capacity than those made with other techniques. Due to the multiplication phenomena, they readily oscillate if care is not taken in the selection of associated circuit constants. However, they are admirably suited to "on-off" switching operation as the "flip-flop" widely used in computers.

The broad area contact devices have noise levels between 10 and 20 decibels, gains on the order of 40 decibels, and in some cases with certain circuit connections have shown current gains as high as 95. Since no actual multiplication of carriers occurs, they are inherently stable with any circuit connection. Their power capacities have no inherent limitations, but at the moment their operation is limited to frequencies on the order of 1 megacycle. These devices, particularly the solid contact ones, are in their infancy. See Figure 6 and the title picture. The latter shows a diffused junction $p$-$n$-$p$ miniature transistor compared to a subminiature vacuum tube. Further progress is limited only by our ignorance of the mechanisms and techniques involved. Only continued intensive investigation can remove that limitation.

# A Carrier Telegraph System for Short-Haul Applications

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**This compact frequency-shift carrier telegraph system provides channels in and above the voice range. The channel terminal unit incorporates arrangements for handling Teletypewriter Exchange Service supervisory signals and employs no electromagnetic relays.**

MOST SHORT Bell System telegraph circuits, particularly those in the less densely populated areas of the country, have customarily been operated over d-c facilities obtained by compositing or simplexing physical telephone circuits. Many of these extend from a telegraph repeater in a central office to another arranged as a subscriber set and mounted in the kneewell of the customer's teletypewriter table. Thus, for example, circuits are extended to Teletypewriter Exchange Service (TWX) subscribers located far from the switchboard. The TWX facilities are arranged to handle supervision as well as transmission.

During and since World War II, the growth of the Bell System's telegraph business resulted in some shortage of d-c facilities. It was foreseen that this shortage would be rapidly intensified by the use of new short-haul carrier telephone systems, such as the *N-1*[1], in providing telephone circuits without adding physical conductors. Moreover, existing d-c facilities would be absorbed to meet signaling needs for the rapid expansion of telephone toll dialing. It therefore became evident that carrier telegraph methods must be adopted for relatively short hauls in fringe areas.

The existing *40C1* voice-frequency carrier telegraph system[2,3] was designed for application in large groups at telegraph central offices and for trunk-service operation over toll telephone circuits employing standard levels. It has proved very economical in this field. However,

Full text of a conference paper recommended by the AIEE Committee on Telegraph Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. It is a condensed version of full paper in the *Bell System Technical Journal*, July 1952.

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the very features which make for economy in large installations (such as amplitude modulation, common carrier supply and testing equipment, and standardized operating conditions) cause this equipment to be costly when it is applied a few channels at a time in outlying offices; these may not be equipped with either telegraph battery supplies or telegraph boards. Moreover, the *40C1* equipment includes no means for handling TWX supervisory signals. Where TWX supervision is involved, rather complex additions are necessary.

Consequently, it was decided to develop a new carrier telegraph system especially aimed at the needs of fringe areas. One of the problems to which much thought was given concerned the chcice between amplitude modulation and frequency-shift operation. A frequency-shift system provides some reduction in the effect of noise and other interference on transmission and is less affected by rapid level changes. Although these advantages were attractive, it was not clear that they were sufficient to justify the added complexity and cost entailed by the adoption of this type of transmission, in view of the quiet and stable circuits encountered in the Bell System plant. What finally swung the balance to a frequency-shift system was its advantage for handling TWX supervisory signals. With transmission accomplished by shifting the carrier frequency, supervisory signals could be sent by turning the carrier on and off. A cheap and simple circuit then might be used to distinguish between transmission and supervision.

From the foregoing discussion it will be evident that during the 13 years since the *40C1* system was developed, the needs of the Bell System have changed. Fortunately, the designer's art has concurrently made great strides in making available new miniature apparatus and electronic techniques such as have been exploited so successfully in the *143A*-type electronic telegraph regenerative repeater,[4] the *V3* telephone repeater,[5] and the *N-1* carrier telephone system. As a result, the channel terminal of the new *43A1* Carrier Telegraph System, being small, inexpensive, and self-contained, is almost ideally suited to the needs of the smaller central offices.

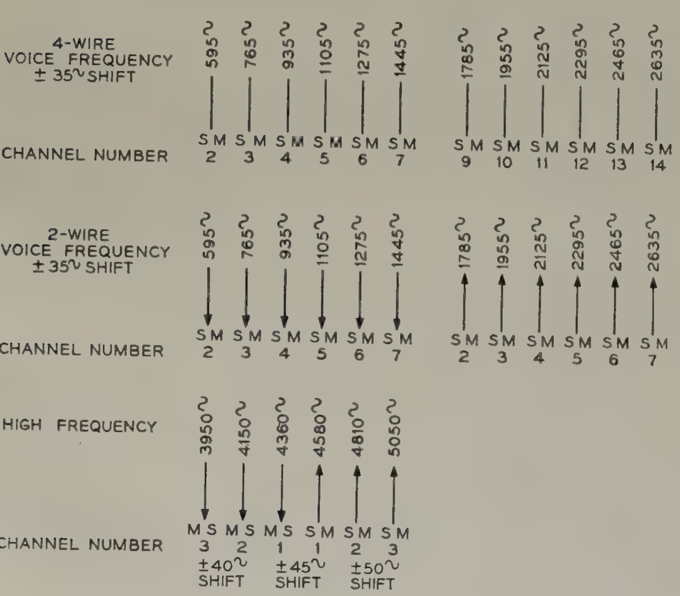


**Figure 1. Frequency allocations**

## FREQUENCY ALLOCATIONS

The *43A1* system provides two groups of channel-frequency allocations, as follows:

1. A 3-channel high-frequency allocation, using frequencies between the upper edge of the voice-frequency band and the lower edge of the type-*C* carrier telephone band. This allocation is primarily for operation on open-wire lines but can be operated also on cable circuits where the loading provides a suitably high cutoff.

2. A voice-frequency allocation capable of providing 6 channels on 2-wire circuits or 12 channels on 4-wire circuits. The channels of this allocation are for operation over telephone speech channels on any of the standard facilities, including broad-band carrier and cable or open-wire physical circuits.

Figure 1 shows the present frequency allocations. The voice-frequency system is based on 12 nominal mid-band frequencies spaced 170 cycles apart from 595 cycles to 2,635 cycles, omitting 1,615 cycles. The carrier frequency is shifted ±35 cycles about mid-band, and either the higher or the lower frequency may be used for marking signals. The high-frequency system is based on six mid-band frequencies spaced from 200 to 240 cycles apart. The frequency shift ranges from ±40 cycles in the lowest channel to ±50 cycles in the highest. These wider spacings and shifts were adopted to ease the problem of designing inexpensive filters and oscillators for the higher frequencies.

Channel 1 of the high-frequency system employs adjacent frequency assignments for the two directions of transmission. The lower frequency path employs a downward shift and the higher frequency path an upward shift for marking signals. In half-duplex operation, this minimizes interference from the strong signals at the transmitter output to the weak signals at the receiver input, because the steady marking frequency, sent against the flow of traffic, is shifted away from the band over which the message is passing.

## TRANSMISSION FEATURES

The sending level may be adjusted to any value between 6 decibels above and 26 decibels below one milliwatt. The actual value employed will depend upon the standard or maximum permissible level for the particular line facility involved.

On lines that are sufficiently quiet, received levels as low as 45 decibels below one milliwatt may be employed.

On quiet circuits, total telegraph distortion per section averages 1 or 2 per cent at 60 words per minute and about 5 per cent at 100 words per minute.

## CHANNEL TERMINAL CIRCUIT

Figure 2 is a diagram of the channel terminal circuit. In many ways it is a conventional frequency-shift circuit; only the noteworthy features will be described in the following.

*Modulator.* The oscillator is tuned to the higher of the two signal frequencies by an inductor-capacitor combina-

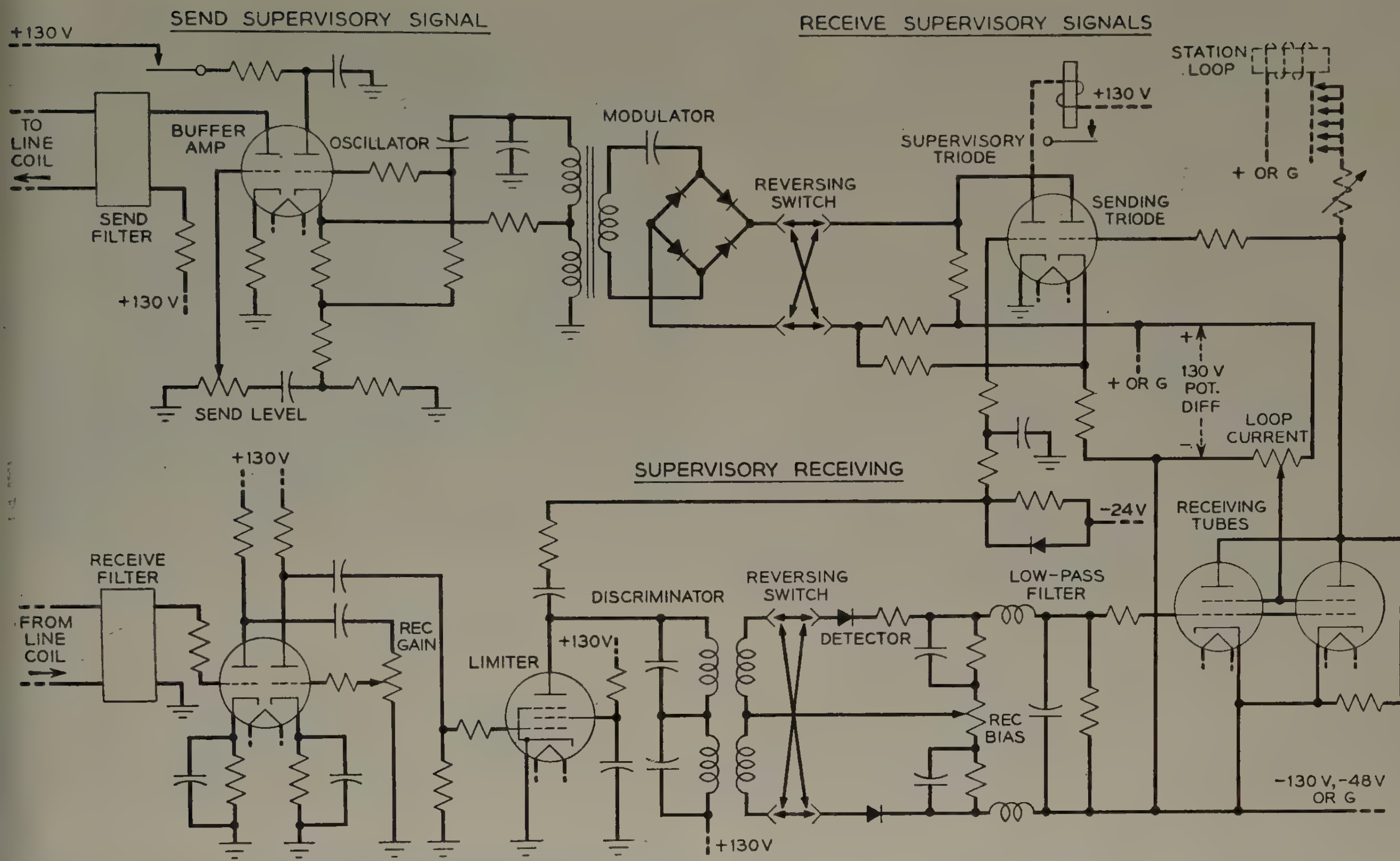


**Figure 2. Simplified diagram of channel terminal circuit for half-duplex operation**

tion. A germanium varistor bridge acts as a switch to connect an additional capacitor which shifts the frequency downward.

A reversing switch in the driving circuit of the modulator permits either the higher or lower frequency to be used for the marking condition.

*Supervisory Circuit.* When the channel is used in TWX service as a toll subscriber line, the subscriber calls by applying plate voltage to the transmitting oscillator. At the distant switchboard terminal, the receipt of carrier current energizes a supervisory receiving circuit which is fed by the plate circuit of the limiter. The output of this circuit is capable of actuating supervisory relays.

Recall and disconnect signals are sent by removing the oscillator plate voltage, momentarily for recall, permanently for disconnect. At the central office, these signals de-energize the supervisory receiving circuit and cause a flashing or steady lamp, respectively, at the switchboard. The telegraph receiving circuit remains marking during recall and disconnect signals; hence these supervisory signals do not pass through the cord-circuit repeater to the TWX toll line. Moreover, supervisory signals may be passed from station to central office regardless of whether a marking or a spacing signal is being sent from central office to station.

A resistance-capacitance circuit slows the rise of current in the supervisory receiving tube to guard against false operation due to noise impulses during the carrier-off condition. Though Figure 2 shows both types of supervisory signal, a given channel terminal is equipped for but one type: the send type at the subscriber station, and the receive type at the switchboard.

*Impedance Transformations.* Transformers are used only in the oscillator and discriminator networks.

The sending filter contains a downward transformation from the impedance of the buffer amplifier to that of the line, and the receiving filter contains an upward transformation from the line impedance to a value suitable for driving the grid of the first amplifier stage.

Either unity-ratio line coils or a hybrid coil may be used to connect the unbalanced sending and receiving filters to a balanced line. The hybrid coil is used with a 2-wire line when the send and receive frequencies occupy adjacent bands.

*Detector and Final Stage.* Nearly all the voltage gain of the receiver appears ahead of the detector. The detector output voltage is sufficiently high to drive the grids of the beam-power tetrodes which control the loop current. Hence, no intermediate stage of d-c amplification is needed following the detector. The detector is unbalanced, the negative output voltage being larger than the positive, and this unbalance furnishes the biasing voltage for the final stage. A low-pass filter between the detector and last stage attenuates interference which exceeds 40 cycles per second in frequency.

These arrangements permit great freedom in the assignment of loop voltage. The cathodes of the final stage may be fixed at −130-volt, −48-volt or ground potential, and the plates operated from ground,

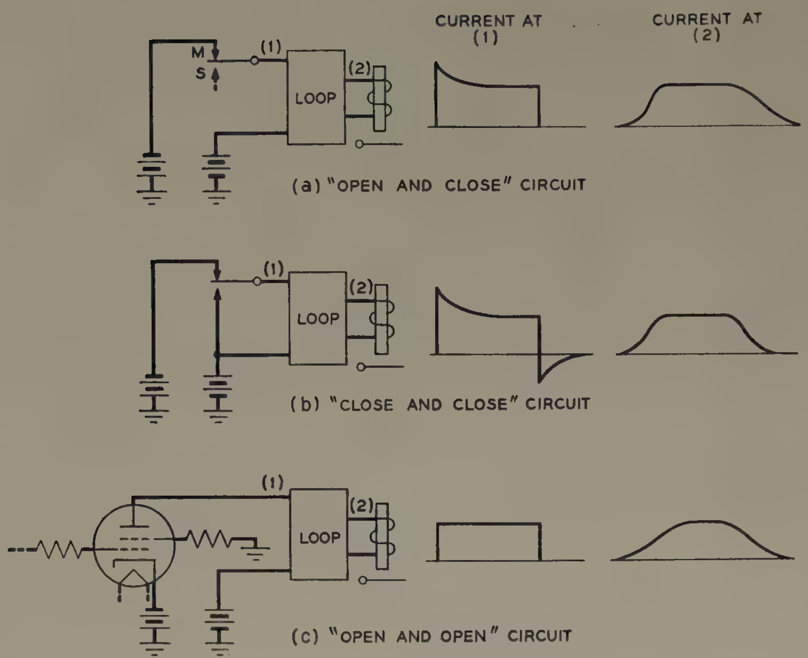


**Figure 3. Explanation of electronic loop circuit**

+48-volt, or +130-volt potential. The remainder of the circuit employs +130 volts for the plates and −24 volts for the heaters of the tubes, regardless of the loop conditions.

By means of a reversing switch, current may be caused to flow in the loop during the reception of the higher or the lower frequency. Thus, not only can various frequency allocations be accommodated, but the local circuit may be operated neutral, with current for mark, or inverse neutral, with no current for mark.

One tube is used in the final stage for 20- or 30-milliampere loop current, and two for 60-milliampere loop current.

*D-C Circuits.* On the d-c side of the channel terminal, provision is made for optional wiring arrangements to connect to the circuits of the various telegraph testboards, service boards, and TWX switchboards, as well as to local teletypewriter loops, using telegraph voltages of either 130 or 48 volts. In offices where a negative 130-volt battery is not provided, operation with a single positive 130-volt battery is possible.

The loop connections are made to an electronic circuit in the channel terminal which is similar to that employed in a recently-developed electronic loop repeater used in telegraph offices, and which possesses several interesting features. Figure 3 compares the action of this circuit, in transmitting toward the subscriber station, with that of more conventional arrangements.

Figure 3*A* shows a conventional open-and-close circuit with the waveshapes it produces at the central office end and at the far end of a capacitative loop. As is well known, the asymmetrical waveshape causes positive signal bias.

Figure 3*B* shows an "effective polar" circuit along with the waveshapes it delivers. This is the circuit conventionally used to drive subscriber loops. It presents a constant low impedance to the loop. Therefore, it might be considered a "close-and-close" circuit.

Figure 3*C* shows the electronic loop circuit. The driving tetrodes are operated in their high-impedance region, above the knee of the plate-current plate-voltage curve. They deliver a highly symmetrical rectangular wave to the loop, and little or no bias results. This circuit presents nearly a constant high impedance to the loop, and might be considered an "open-and-open" circuit.

Although the rectangular wave is inferior to a peaked wave in that less average power is delivered for the same values of steady-state current and voltage, it provides entirely acceptable transmission for 19-gauge cable loops up to about 20 to 25 miles long. Inasmuch as 80 volts potential is absorbed in the electron tube plate circuits, this is almost the maximum length over which 62.5 milliamperes can be supplied when a loop battery of 260 volts is used.

During open-and-close transmission by the subscriber, the high-impedance termination of the loop at the tetrode plate circuits causes the current at the central office end of the loop to change very slowly, too slowly for good transmission

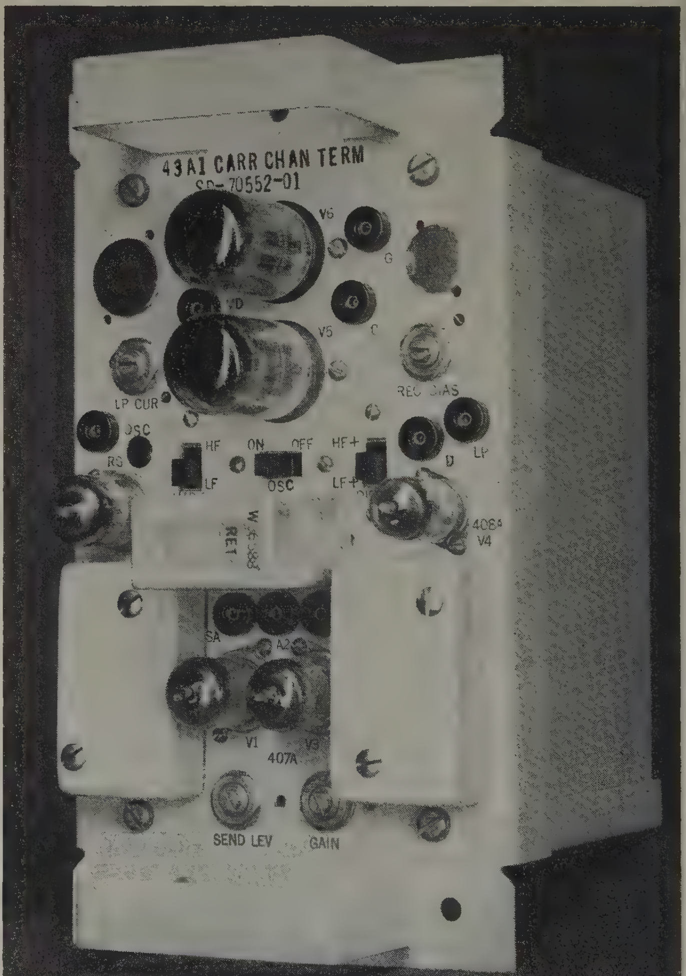


**Figure 4. Front view of channel terminal**

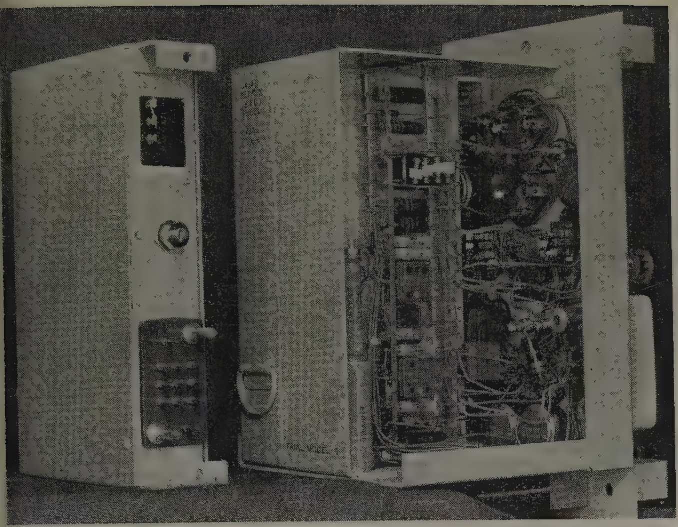

**Figure 5. Rear view of channel terminal with sending network removed**

at teletypewriter speeds. However, the voltage wave is very well shaped, and this is what is used to drive the grid of the transmitting tube. One noteworthy fact is that the bias of the signals transmitted to the line is almost entirely independent of loop length; consequently, no inductive wave-shaping is required at the subscriber station, even in the longest operable loops.

Because of the high-impedance termination, loop current is insensitive to circuit resistance. The loop padding rheostat is adjusted, therefore, to build out the loop resistance to a standard value, and the amount of loop current required for proper operation of the station teletypewriter is obtained by varying the screen-grid potential of the tetrode tubes.

*Duplex Feature.* In half-duplex operation, the voltage at the central office end of the loop goes toward negative when the subscriber opens his contacts, and this causes the transmitting tube to pass a spacing signal. When, in transmission toward the station, the tetrode tubes are cut off to send a spacing signal to the loop, the voltage at the office end swings toward positive. Although the loop current is reduced practically to zero at this time, the voltage applied to the transmitting tube is still controlled by the opening and closing of the teletypewriter's sending contacts. Thus signals outgoing to the line are not interrupted by the receipt of a spacing signal from the line.

For full-duplex operation, the grid of the sending tube is disconnected from the plates of the tetrodes and transferred to a resistive connection which terminates the full-duplex sending loop.

## EQUIPMENT FEATURES

The channel terminal employs a formed sheet-metal framework and occupies a space $10^1/_2$ inches high, $5^1/_4$ inches wide, and $7^3/_4$ inches deep over-all. Figure 4 shows the *43A1* channel terminal. It is plug-terminated, and hence removable for maintenance or repair at a bench.

The basic portion of the channel terminal is common to all frequency allocations. The oscillator network and send filter, which constitute the elements determining the transmitted frequency, form a plug-terminated subassembly $7^3/_4$ inches high, $5^3/_8$ inches wide, and $1^1/_2$ inches deep. The receive filter and discriminator, which select the received frequency, form a plug-terminated subassembly of the same size.

Figure 5 shows a rear view of the channel terminal with the send-frequency unit removed. With both frequency units in place, the rear of the channel terminal is almost completely enclosed. When they are removed, the wiring and apparatus terminals of the basic channel terminal are readily accessible for test and repair.

Tube sockets, potentiometers, test points, switches, and the inductor of the low-pass filter are mounted on the front panel. Small resistors, capacitors, and germanium diodes are assembled on a plastic ladder which is mounted vertically in the space between the frequency units.

Three channel terminals may be mounted abreast on a welded metal frame which is fastened to any of the standard bay frameworks, designed to accommodate 19-inch mounting plates. The unit mounting frame carries the multicontact receptacles into which the channel terminals are plugged. Twenty-four channel terminals may be mounted on an $11^1/_2$-foot relay rack, with line coils and certain auxiliary equipment.

Where arrangements for switching between half- and full-duplex operation are required, duplex switches for a number of channel terminals are mounted on a narrow plate between the channel terminal mounting frameworks.

Loop rheostats, when required, may be mounted adjacent to the channel terminals or in a loop pad bay along with other loop rheostats that may be associated with electronic loop repeaters. The latter arrangement concentrates the heat dissipated by these rheostats at a place where it will not be harmful.

*Subscriber Set.* A channel terminal also may be mounted in a station set appearing in the kneewell of a subscriber's teletypewriter table. This *130B1* teletypewriter subscriber

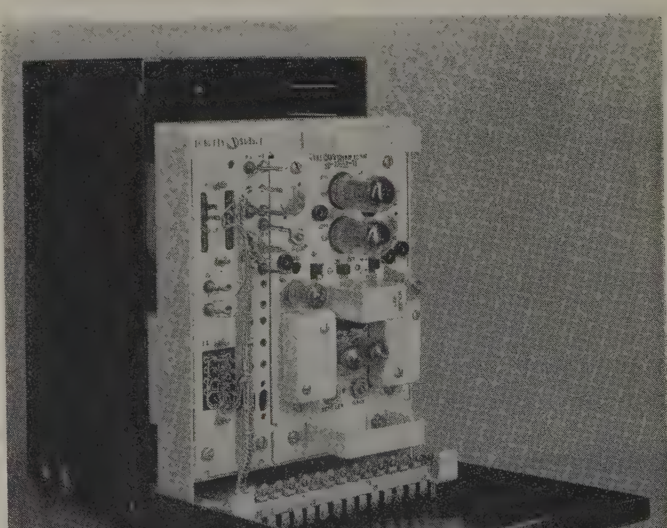

**Figure 6. Front view of 130B1 teletypewriter subscriber set including channel terminal**

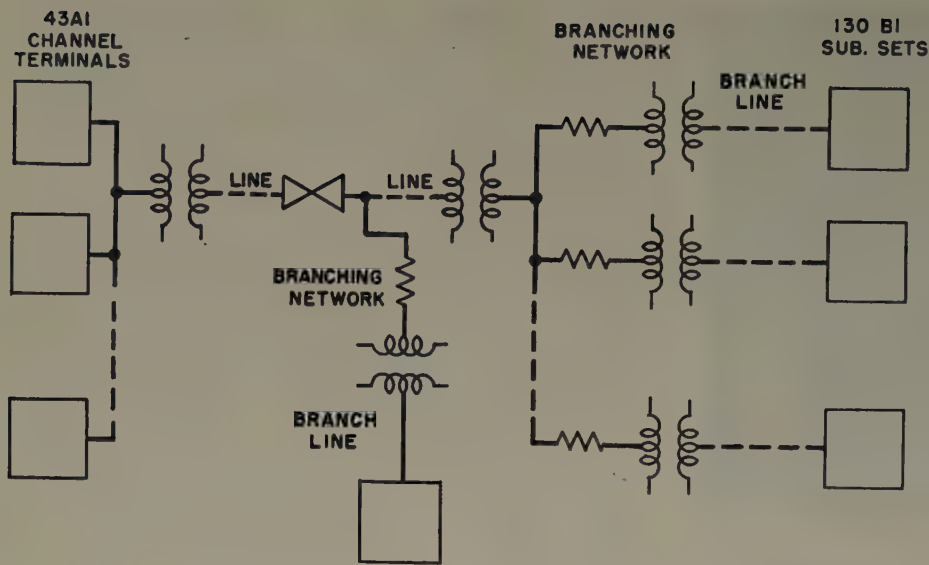

Figure 7. Circuit with branch lines

set is illustrated in Figure 6. It contains a line or hybrid coil and balancing network, as well as local circuit resistors and other miscellaneous apparatus. When so mounted, the channel terminal is powered by the teletypewriter rectifier, which furnishes 130-volt d-c and 20-volt a-c power.

The *130B1* set may be employed in private-line or TWX service. In the latter, the application and removal of the oscillator plate battery is controlled by the teletypewriter power switch, so that the equivalent of telephone "switch-hook" supervision is attained.

On a TWX call to the subscriber station, a series of alternate marks and spaces, generated by applying 20-cycle ringing voltage to the grid of the sending tube at the central-office terminal, actuates the station ringer, which is connected to the local loop whenever the teletypewriter power switch is in the OFF position.

*Power Drains.* A channel terminal dissipates about 25 watts. Vacuum tube heaters consume about half an ampere at 24 volts and the remainder of the channel terminal, exclusive of its loop terminating portion, consumes 50 milliamperes at 130 volts. The loop terminating portion dissipates 20, 30, or 62.5 milliamperes at 80 volts, depending upon the current delivered to the local circuit.

## BRANCHING AND DROPPING CHANNELS

Many of the applications met with in outlying sections require channels extending from a main telegraph central office to a number of subscriber stations on small telephone central offices. For this use, arrangements have been provided for branching from an outlying office to a number of scattered channel terminals and for dropping channels along the line, as illustrated diagrammatically in Figure 7. These arrangements will obviate back-hauling and increase the efficiency of line usage in fringe areas.

## FUTURE EXTENSIONS

It is expected that the field of application of the *43A1* system will be broadened by further development over the next few years. More frequencies will be provided, both in and above the voice band. Means will be designed for passing TWX supervisory signals over a d-c loop from a subscriber station to a channel terminal installed in a nearby central office. The built-in supervisory arrangements of the *43A1* equipment will be exploited to obtain inexpensive straightforward trunks for use both between TWX switchboards and from switchboards to line concentrating units.

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# Sequence Tester Automatically Checks Multiple-Circuit Relays

An improved relay sequence tester is being used in the functional test laboratory at Temco Aircraft Corporation, Dallas, Tex., to test multiple circuit relays automatically and with an estimated 90 per cent man-hour savings over methods previously used.

Previous to the development of the new tester, there were 20 tests to be made on each relay, with the inspector changing test leads manually from one terminal to another for each test.

This tester is an adaptation of the one formerly used, with the addition of two 24-point step relays and a timer motor with a 3-lobe cam. Contact is made with all terminals by means of a contact platen which clamps firmly on the relay to be tested. A different platen is required for each type of relay to be tested. The tester is turned on by the operator and performs all the necessary tests automatically and in the correct sequence. In the event of a fault or defective relay, a safety circuit stops the tester and turns on a red light on the panel. A dial on the test panel enables the inspector to locate the defect at a glance. Short circuits and burned terminals have been eliminated completely.

# Vacuum-Plastic-Filled Insulated Voltage Transformers

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VOLTAGE TRANSFORMERS for voltages up through 14,400 volts have been manufactured as dry-type units for many years because there always has been a strong demand that oil-filled apparatus be eliminated from the switchgear and meter boxes in which these units were installed.

Dry-type transformers had notoriously low impulse strength. Compound-filled transformers were better but were not uniformly strong. It was determined that the secret of high strength lay in filling compound-filled transformers under vacuum with compound which has been melted under vacuum.

That this principle of vacuum plastic filling is the secret of success has been shown by nearly 20 years of use with a Moldarta-Micarta insulation structure, but a number of detail problems had to be worked out: 1. refinements in insulation structure; 2. low and high temperature phenomena; 3. mechanics of filling procedure.

The latest insulating structure shown in Figure 1 has several important advantages.

1. The coil is more fully enclosed, and yet there are more available passages for the insulation compound to flow into the layers of the coil.
2. The crepe paper can be dried easily and thoroughly during the vacuum drying and filling process. The result is a uniformly low insulation power factor.
3. The corrugated nature of the crepe paper not only provides longer effective creep distances but adheres more firmly to the compound, resisting development of any voids at very low temperatures.
4. The crepe paper, impregnated in the compound, has excellent dielectric strength, particularly against impulse voltages. The effectiveness of this coil structure is shown by tests; sample units designed for 95-kv impulse level were tested up to 300-kv impulse without damage. A large number of units have been tested for insulation power factor; the measurements average below 2 per cent.

**Figure 1. Latest crepe paper insulation structure permits more complete enclosure and insulation with a material of higher dielectric strength which can be thoroughly dried to get low insulation power factor**

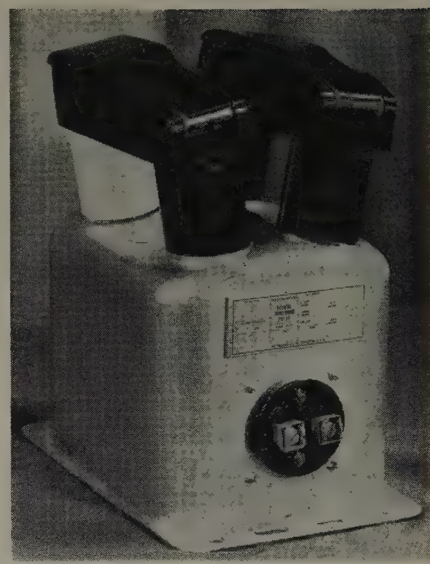

**Figure 2. New 2,400-volt design which incorporates the latest type of insulation for high dielectric strength at low temperatures and foam rubber expansion absorbers for preventing excessive pressures at high temperatures**

The effect of low temperature might be to produce voids, but extensive tests down to −50 degrees centigrade indicate that the crepe paper structure is much better than the older molded spool structure, which in turn has given good service in the field.

Expansion at high temperature is taken care of by flexing of the case wall and by foam rubber fillers.

Tests have been made with rated thermal burden at ambient temperatures as high as 55 degrees centigrade without developing dangerous internal pressure. The pressure at normal operation is considerably less than 5 pounds. Cycling tests made on the case by blowing it up with air pressure indicate that the welds are not damaged nor the gasket seals broken by many thousand cycles.

The cases are filled while the vacuum is maintained in the oven and the hot compound entering the case thoroughly impregnates the coils and solidly fills the case.

Solder-sealed bushings have not been adopted principally because they are difficult to replace in a compound-filled transformer. The compound filling is naturally water-repellent, and cemented cork-neoprene gaskets have been shown to be effective in sealing the transformer.

A 2,400-volt transformer using this type of insulation is shown in Figure 2.

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Digest of paper **52-79**, "Recent Improvements in Theory and Practice of Vacuum-Plastic-Filled Insulation for Voltage Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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# Magnetic Regulation in Small Rectifiers

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THE PRESENT TREND of developing static, maintenance-free telephone equipment is highly justifiable in power-supply design, and when it was necessary to furnish a small battery charger for the Bell System Transcontinental Microwave Radio Relay, effort was concentrated on magnetic-amplifier regulation methods.

The end result of the studies was a rectifier unit rated 24 volts d-c at 9 amperes, and this rectifier has served as a prototype for other sizes. The circuit of the rectifier is shown in Figure 1.

The line regulator is a ferro-resonant circuit serving to reduce line-voltage variations of ±8 per cent to ±1 per cent or better.

The operation of the load-regulating circuit is based on the variations of the impedance of the primary winding of saturable transformer, *T*1. The impedance is adjusted by the degree of saturation in the center leg of the core and is a function of the currents in the shunt and series d-c windings on the center leg.

The shunt winding contributes a relatively constant amount of flux, opposed by the variable flux generated by the load current through the series d-c windings. The net d-c flux in the core is high at no load and almost zero at full load.

The alternating voltage across the primary of *T*1 is thus made to increase in proportion to the losses in the system, since the impedance of the primary is low at no load and high at full load.

Maximum correction is obtained at full load because the ampere-turns of the two d-c windings are equal and opposite, resulting in minimum saturation and maximum primary impedance. Current limiting is effected above full load when the series d-c winding begins to resaturate the core, reducing the output voltage rather sharply due to the combined action of the series and shunt windings. Overload protection is thus obtained.

Several years of field experience with this circuit indicate that the battery voltage may be maintained to within ±1 per cent, with line-voltage variations of ±8 per cent and load variations of zero to 9 amperes, and that the design criterion of 20-year trouble-free life expectancy should be realizable.

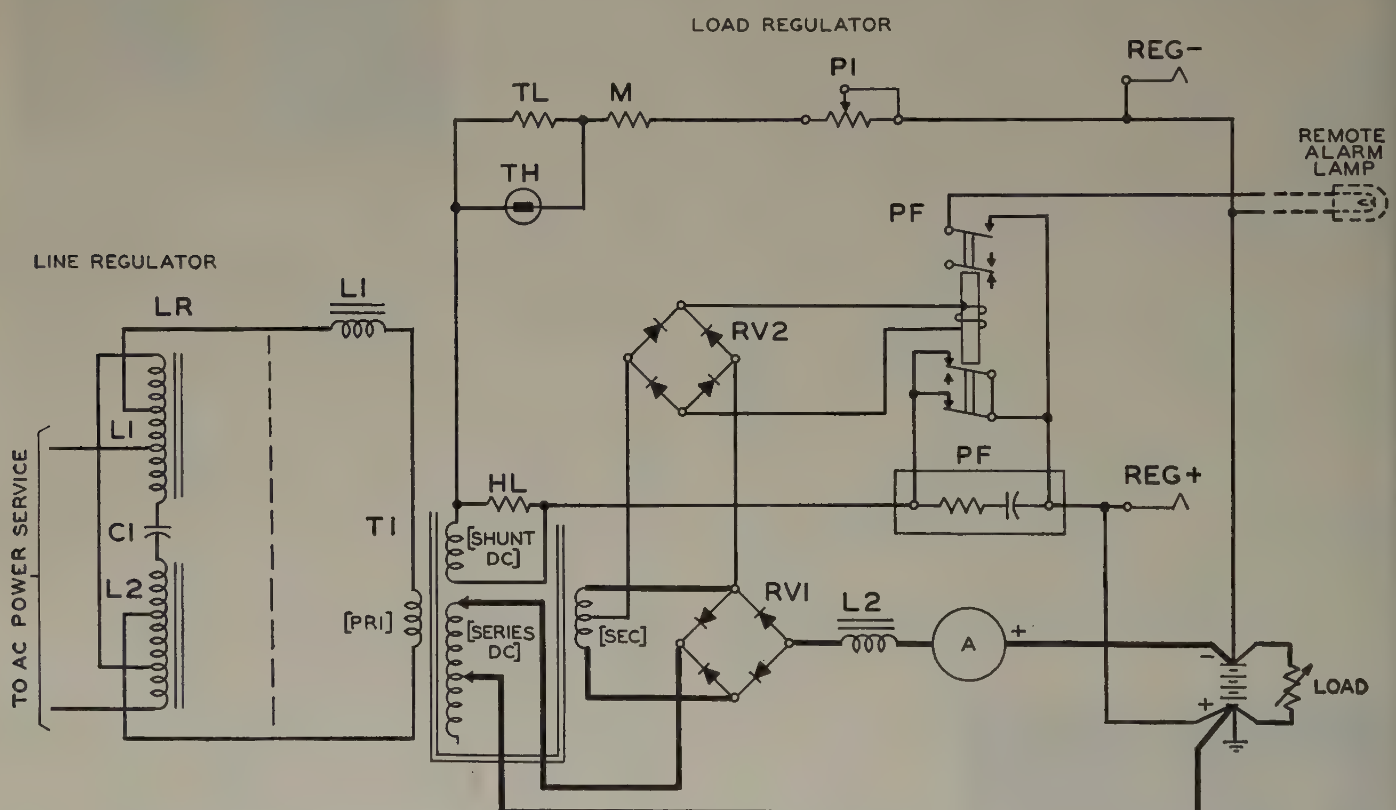


**Figure 1. Magnetically regulated rectifier circuit. Output is 24 volts at 9 amperes**

Digest of paper 52-102, "Automatic Regulation of Metallic Rectifiers by Magnetic Control," recommended by the AIEE Committee on Metallic Rectifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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# Lighting a Network Analyzer Area

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ELECTRIC POWER SYSTEMS have grown tremendously in the first half of the 20th century. As the number of loads, paths for power flow, and generator sources increase, the problem of making electric system calculations of all varieties becomes more complex. To perform these necessary calculations economically, utility planning engineers have used network analyzers such as the one purchased by the American Gas and Electric Service Corporation.

It is the purpose of this article to study the visual requirements in a network analyzer area and to suggest means of providing visual comfort through lighting.

In the office and conference areas the work includes slide-rule calculations, report writing, system map preparation, tabulation of board data, and interpretation of results. This involves visual tasks of a critical nature calling for discrimination of fine detail over prolonged periods of time. The work plane is mainly horizontal.

In the analyzer room, operations are as follows. The system network is plugged on the board by one operator while the other dictates aloud the values to be adjusted and the connections to be made. In this process critical seeing tasks on both the vertical and horizontal planes are encountered, but each operator can position himself as close to the task plane as is necessary.

After the system conditions are established on the analyzer, the required data are read from light beam galvanometers by an operator. The ability to observe these indications is a function of the brightness contrast between the light beam and the translucent background through which it is observed. This condition limits the vertical illumination level in the area. While an operator at the control desk reads aloud values indicated by the meters, his associate records data on appropriate diagrams. Thus the visual tasks are different. A critical task exists on the horizontal plane requiring a relatively high illumination level but the task on the vertical plane must not be illuminated excessively.

A review of these factors suggests a minimum illumination of about 50 foot-candles on the horizontal plane of all areas. On the vertical plane more than one level of illumination seems desirable to meet the two kinds of critical seeing tasks mentioned. It was considered that 40 foot-candles, 66 inches above the floor, should be satisfactory and that no more than 20 foot-candles, 48 inches above the floor, should be necessary while the galvanometers are read.

Having established the character of work and seeing tasks involved, one may now consider the following major fundamentals which must be obtained to effect a reasonable lighting solution. Vertical illumination on the network analyzers should be adequate to allow comfortable vision of the many adjustable resistance, inductance, and capacitance elements, their associated numerical scales as well as those within the glass-faced instruments. Vertical illumination on these surfaces should not be so high to cause difficulty in reading the light-beam galvanometers.

Illumination on the vertical plane should be reasonably diffused to minimize shadows, especially on instrument scales. Light sources must not present themselves as images of specular or veiling glare in glass faces of instruments or other surfaces from operators' usual working positions. Light sources must not present themselves as brightness areas in competition with the object being observed; namely, instrument scales and the markings of adjustable elements on the analyzers.

Horizontal illumination on working surfaces should be adequate for the task. In all cases it should be reasonably diffused and the source or any secondary reflecting surface should not cause reflected glare from the horizontal plane. The brightness contrasts between various surfaces in the operators' normal fields of view should not cause the visual surrounding to be uncomfortable.

The degree of perfection obtained in each category should justify the actual cost of each incremental gain. In addition to these lighting fundamentals, certain factors which influence lighting must not be disregarded. A good lighting installation requires not only a proper level of illumination, proper quality of illumination, and proper arrangement of lighting fixtures, but also proper reflecting surfaces within the room, both those which make up permanent structures of the building and furniture which is utilized within the area.

After considering the foregoing factors one must realize also that the selection of a lighting method is controlled to an appreciable extent by aesthetic appearance, ease of maintenance, type of air-conditioning facilities, and atmospheric conditions. The many advantages of fluorescent lighting make these lamps preferred for most office lighting problems but an a-c source of power is a prerequisite.

For the analyzer area in this instance it was felt most appropriate to utilize the direct lighting technique using shallow troffers equipped with Holophane *9015* lens plates. The shallow troffers allow a greater unobstructed ceiling height which enhances architectural treatment in the room. Lens plates give the ceiling a neat appearance without distracting the worker. Mostly two lamp troffers equipped for 40-watt hot-cathode fluorescent tubes were specified. In the a-c analyzer room three lamp units were used in troffers of the rectangle adjacent to the board.

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Digest of paper **52-119**, "Lighting a Network Analyzer Area," recommended by the AIEE Committee on Computing Devices and approved by the AIEE Technical Program Committee for presentation at the AIEE North Eastern District Meeting, Binghamton, N. Y., April 30–May 2, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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# Intermittent Faults in Aircraft Electric Systems

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**Intermittent faults were obtained experimentally in simulated 30-volt d-c, 120-volt d-c, and 120/208-volt 400-cycle a-c electric systems to determine the approximate minimum fault current magnitude and duration. These are discussed along with ways of attaining partial and complete protection against faults.**

IN MOST ELECTRIC systems in military aircraft, a grounded installation is used, that is, the conducting parts of the airplane structure form the electrical return path to the generator. The cables may be bundled and secured to the airplane structure for support with the cable insulation preventing metal-to-metal contact. In an installation of this kind, contact between an energized cable and the airplane structure with current flowing through this junction constitutes an electrical fault.

Electrical faults may be considered as being either of two types, depending upon the nature of the contact at the point of the fault. The first type of fault is characterized by continuous metal-to-metal contact between the electric conductor and the airplane structure. The contact resistance may be high or low in magnitude depending upon the number of conductor strands in contact, the contact pressure, and the contamination of the contact surfaces. This type of fault usually results in damage to the electric system. In order to minimize damage from this type of fault, the fault-sensing device operating time should be correlated with the smoking time characteristic of the conductor being protected or with the current-time characteristic of equipment being protected.

A second type of fault in an aircraft electric system is characterized by separation of a faulted cable and the aircraft structure after contact has been made. Such separation may be intermittent or fixed and may result in a damaging arc being drawn out. Because of the intermittent nature of the second type of faults, large areas of the airplane structure may be melted or vaporized by the arc while the faulted cable, a short distance from the arc, is not excessively hot.[1–4]

An intermittent fault may be described by the current magnitude and fault pulse duration. However, the fault current magnitude and duration depend upon the number of wire strands in contact with the airplane structure, the contact pressure of each strand, the contact area, the variation of arc length with time, the surface contamination and other parameters. In order to describe faults which exist in aircraft, it is necessary to know the exact manner in which the fault is established. Such information is not available, and it is assumed that electrical faults in aircraft can be caused by parting a conductor in any number of ways. In order to determine the approximate minimum fault current magnitude and duration, many light-contact line-to-ground faults were established in simulated 30-volt d-c, 120-volt d-c, and 120/208-volt 400-cycle a-c systems.

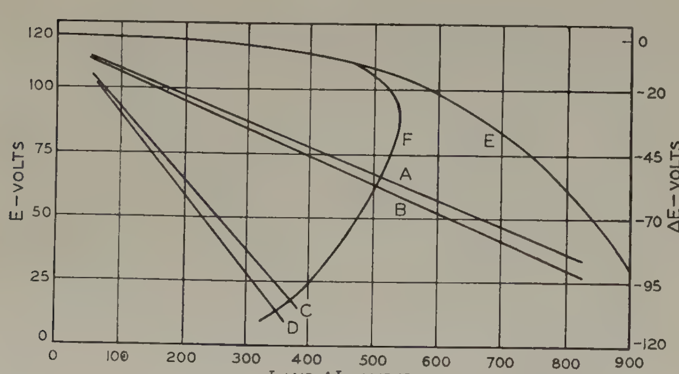


**Figure 1. Steady-state and transient characteristics of the 30-volt d-c electric system used in the study of electrical faults. Curves for transient characteristics (system composition and load):**

*A—1 generator, 1 battery; 200 amperes*
*B—1 generator, 1 battery; no load*
*C—1 generator; 200 amperes*
*D—1 generator; no load*

**Curves for steady-state characteristics (system composition):**

*E—1 generator, 1 battery*
*F—1 generator*

## THE FIRST FAULT PULSE

THE FIRST FAULT pulse was selected for study since it is desirable to detect a fault of any magnitude and duration if this fault or successive applications of this fault will cause penetration of the aircraft structure. Complete penetration of the aircraft structure or the fuel and hydraulic lines can be an accumulative process whereby the electric arc melts a small amount of the metal structure. This globule of molten metal is forced by the cable, by the structure vibration, or by gravity from the crater, thereby exposing solid metal to the succeeding arc. Such a series of small arc discharges is made possible by the nature of the insulation on aircraft cables. When ignited by the arc, this insulation burns and leaves a brittle residue.

Full text of paper 52-137, "Intermittent Faults in Aircraft Electric Systems," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Table I. Number of Intermittent Faults and Welds Which Resulted From Establishing 2,342 Faults in a 30-Volt D-C Aircraft Electric System

| Plate Thickness (Inches) | Battery On: Number of Arcs | Battery On: Number of Welds | Battery Off: Number of Arcs | Battery Off: Number of Welds | AN Conductor Size Number 16: Number of Arcs | AN Conductor Size Number 16: Number of Welds | AN Conductor Size Number 8: Number of Arcs | AN Conductor Size Number 8: Number of Welds | AN Conductor Size Number 2: Number of Arcs | AN Conductor Size Number 2: Number of Welds | Total Arcs | Total Welds | Total Faults |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 581 | 146 | 556 | 172 | 303 | 179 | 412 | 73 | 422 | 66 | 1,137 | 318 | 1,455 |
| 0.091 | 505 | 166 | 155 | 61 | 185 | 112 | 241 | 51 | 234 | 64 | 660 | 227 | 887 |
| Totals | 1,086 | 312 | 711 | 233 | 488 | 291 | 653 | 124 | 656 | 130 | 1,797 | 545 | 2,342 |

The residue is then separated from the conductor by vibration and thus more bare wire is exposed to continue the intermittent fault.

The data presented concern, for the most part, the first fault pulse of intermittent-type faults. The magnitude and duration of the first fault pulse is approximately the same as the magnitude and duration of the succeeding pulses. The time between the first and second fault pulse is approximately the same as the time between any other two consecutive fault pulses in the intermittent fault.

## ELECTRICAL FAULTS IN A 30-VOLT D-C SYSTEM

The transient and steady-state characteristics of the single generator system used in this study are shown in Figure 1. The parameters considered in establishing the faults are as follows:

*Structure Vibration*
- Frequencies (cycles per second): 0; 15; 30; 50
- Total displacement (inches): 0.0125; 0.05
- Direction: Horizontal and perpendicular to cable run; Horizontal and parallel to cable run; Vertical

*Batteries*
- Connected
- Disconnected

*Faulted Cable*
- Size (number): 2; 8; 16
- Length (feet): 5; 25

*Structure Thickness* (inches): 0.05; 0.091

*Distance From Clamp to Fault* (inches): 2; 8; 12

All of the established faults did not result in arcs. Of the 2,342 faults established, approximately 23 per cent resulted in welded faults and the remaining 77 per cent resulted in intermittent faults. See Table I.

The current magnitudes of the faults on each size conductor varied considerably. For example, the average fault current per pulse on cable size number 16 varied from approximately 40 to over 700 amperes. The average fault currents per pulse on sizes number 8 and number 2 conductors extended from 50 to approximately 1,000 amperes. Additional fault current magnitude and duration data for these faults are given in Figures 2 and 3.

Data from 622 faults established on conductors 5 feet long show a slightly greater number of higher current faults as the structure-vibration frequency increased from 15 to 50 cycles per second. In addition, structure-vibration frequency in this range has no marked effect on the duration of the first fault pulse.

Data from 208 faults established on size number 8 show a small change in the distribution of fault currents for a change in vibration displacement from 0.0125 to 0.05 inch. No effect on pulse duration was noted for this change in displacement.

Data from 619 faults established on conductors 5 feet long show that the direction of vibration has relatively little effect upon the current magnitude of the first fault pulse and causes no marked change in fault pulse duration.

## INTERMITTENT FAULTS IN A 120-VOLT D-C SYSTEM

The transient and steady-state characteristics of the system used in this study are shown in Figure 4. The

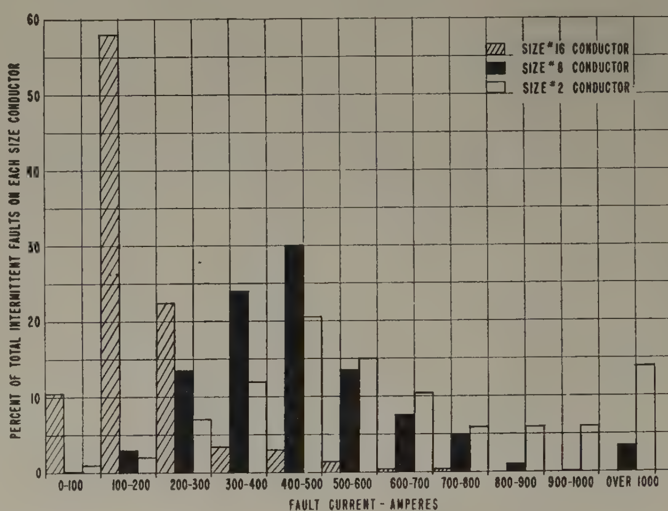


**Figure 2. Current magnitude of the first fault pulse of 621 faults established in a 30-volt d-c system between cables 5 feet long and an aluminum alloy plate 0.05-inch thick**

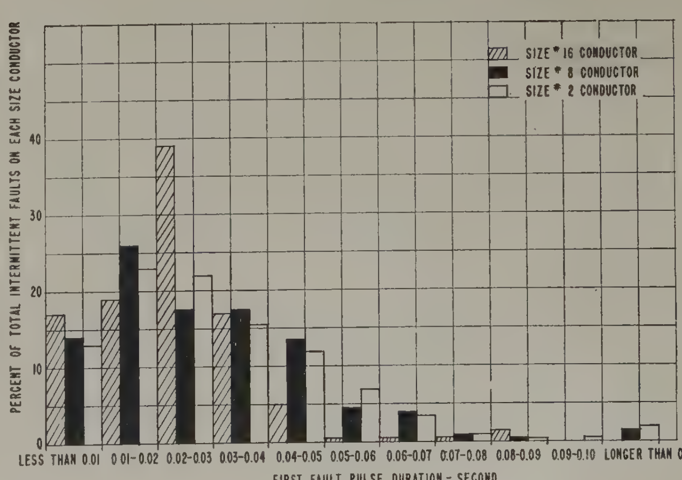


**Figure 3. Duration of the first fault pulse of 614 faults established in a 30-volt d-c system between cables 5 feet long and an aluminum alloy plate 0.05 inch thick**

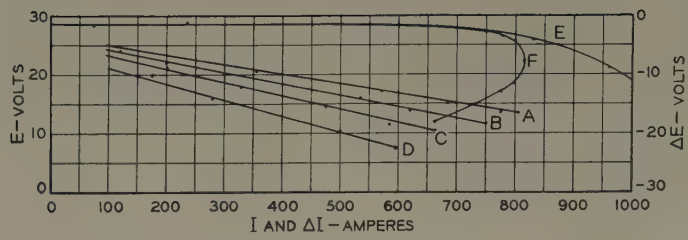


**Figure 4. Transient and steady-state characteristics of the 120-volt d-c electric system used in this study. Curves for transient characteristics (system composition and load):**

*A—1 generator, 4 batteries; 100 amperes*
*B—1 generator, 4 batteries; no load*
*C—1 generator; 100 amperes*
*D—1 generator; no load*

**Curves for steady-state characteristics (system composition):**

*E—1 generator, 4 batteries*
*F—1 generator*

parameters considered in establishing these faults are as follows:

*Structure Vibration*
Frequencies (cycles per second): 0; 30; 50
Total displacement (inches): 0.0125; 0.05
Direction: Horizontal and perpendicular to cable run
Horizontal and parallel to cable run
Vertical

*Batteries*
Connected
Disconnected

*Faulted Cable*
Size (number): 2; 8; 16
Length (feet): 10

*Load Prior to Fault*
No load
100 amperes

Of the 180 faults established, 9 per cent resulted in welded faults; the remaining 91 per cent were of the intermittent type.

As in the 30-volt direct current study, there is considerable variation in fault current for each cable size. For example, the average current per fault pulse on size number 16 cables ranged from 210 to approximately 500 amperes; the average current on size number 8 cables ranged from approximately 275 to over 800 amperes; and fault current on size number 2 cable ranged from approximately 315 amperes to over 800 amperes. See Figure 5.

An increase in structure-vibration frequency from zero to 50 cycles per second results in a slight increase in the number of higher current faults.

Data from 52 intermittent faults established on cable size number 8 show that there is a tendency toward a greater number of higher current faults as the displacement is increased from zero to 0.0125 and 0.05 inch. The direction of vibration has no marked effect on the fault-current magnitude.

To define further the intermittent faults established on a simulated aircraft electric system, it is necessary to know the duration of the first fault pulse as shown on Figure 6. Cable size has no pronounced effect on first fault-pulse duration, although there is a slight increase in duration as the conductor cross-sectional area is increased. Also, structure-vibration frequency has little effect on the duration of the first fault pulse. In addition, structure-vibration displacement has little effect on the duration of the first pulse of fault current. Direction of structure vibration has only a minor effect on the duration of the first fault pulse.

Of the 180 faults established, 41 of these faults caused complete penetration of the aluminum alloy plate within 1 second.

## INTERMITTENT FAULTS IN A 120/208-VOLT 400-CYCLE SYSTEM

The electric power source used for this study is a 40-kva aircraft generator driven by a 50-horsepower motor. Only single-phase faults were established. The parameters considered when faults were established are as follows:

*Structure Vibration*
Frequencies (cycles per second): 0; 30; 50
Total displacement (inches): 0.0125; 0.05
Direction: Horizontal and perpendicular to cable run
Horizontal and parallel to cable run
Vertical

*Faulted Cable*
Size (number): 8; 12; 16
Length (feet): 10

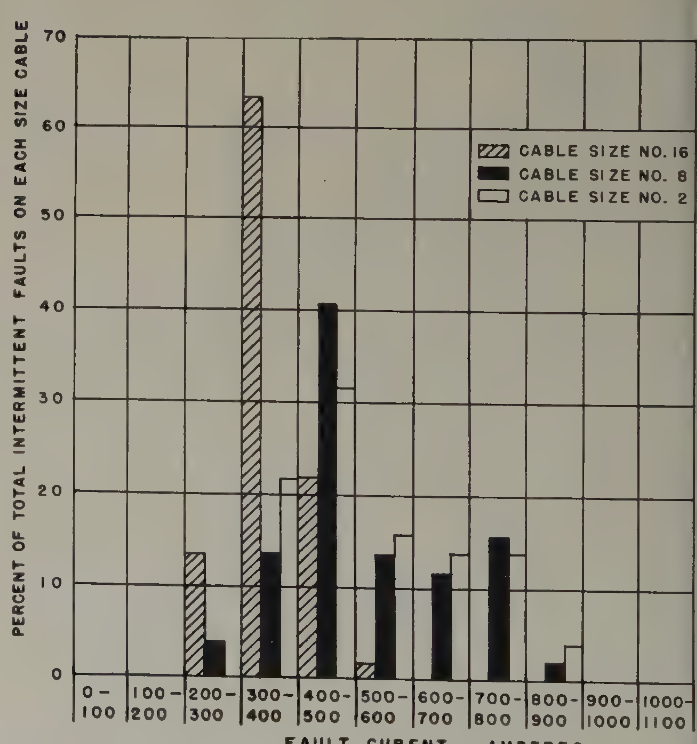


**Figure 5. Current magnitude of the first fault pulse of 163 faults established in a 120-volt d-c system between cables 10 feet long and an aluminum alloy plate 0.091 inch thick**

*Load Prior to Fault*

Type: No load; balanced; unbalanced

Power factor: 1.00; 0.75 (lag)

Of the 225 faults established, approximately 5 per cent developed into welded faults; however, no welds resulted for faults established on a nonvibrating platform.

As would be expected, the test results show that although maximum fault currents occur on the cable with the smaller resistance, a wide range of fault currents were measured on each of the three sizes of cables used. See Figure 7.

The first fault-pulse duration of 98 per cent of the total intermittent faults is less than 0.01 second, and none of the faults established penetrated an aluminum alloy plate 0.091 inch thick within 1 second.

## ANALYSIS OF FAULT CURRENTS

IT WAS FOUND that for a given fault, the average magnitude of the current pulses following the first is approximately the same as for the first pulse. Using the time between pulses, the fault-pulse magnitude and duration, the average fault current can be calculated. These calculated values for faults on a 30-volt d-c system are shown in Table II. Similarly, in the 120-volt d-c system, the average current of the first current pulse of all of the faults struck on size number 16 cable is 200 amperes or greater. The first pulse duration of all of the faults struck on size number 16 cable is 0.01 second or greater, and the time between the first and second faults is 0.3 second or less. These values for number 16 cable give the minimum magnitude of the faults occurring on the simulated 120-volt d-c system used in this study. The average fault current, considered over the duration of several pulses, is calculated to be 5 amperes. The average current of the first fault current pulse of 75 per cent of the faults struck on size number 16 cable is 300 amperes or greater, and the first pulse duration of 75 per cent of the faults struck on size number 16 cable is 0.01 second or greater. The time between the first and second fault pulse of 75 per cent of the faults is 0.05 second or less. From these values, considered over the duration

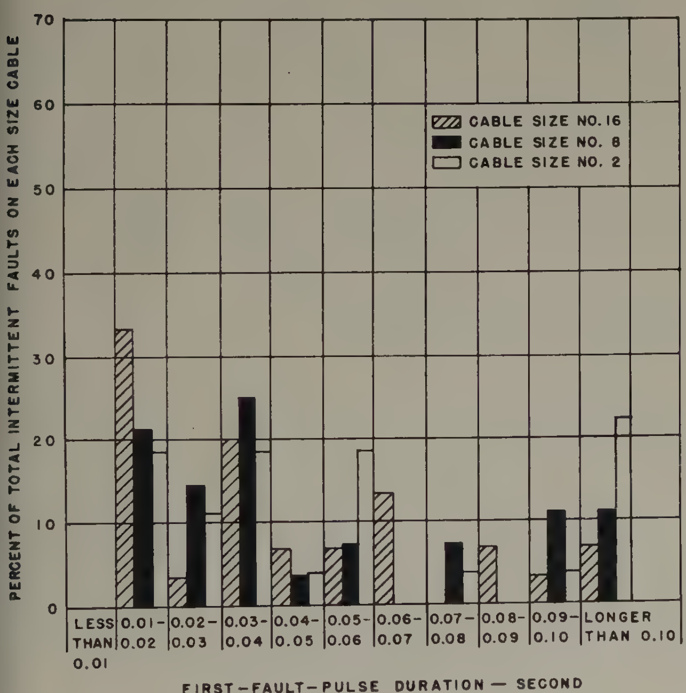


**Figure 6. Duration of the first fault pulse of 85 faults established in a 120-volt d-c system between cables 10 feet long and an aluminum alloy plate 0.091 inch thick**

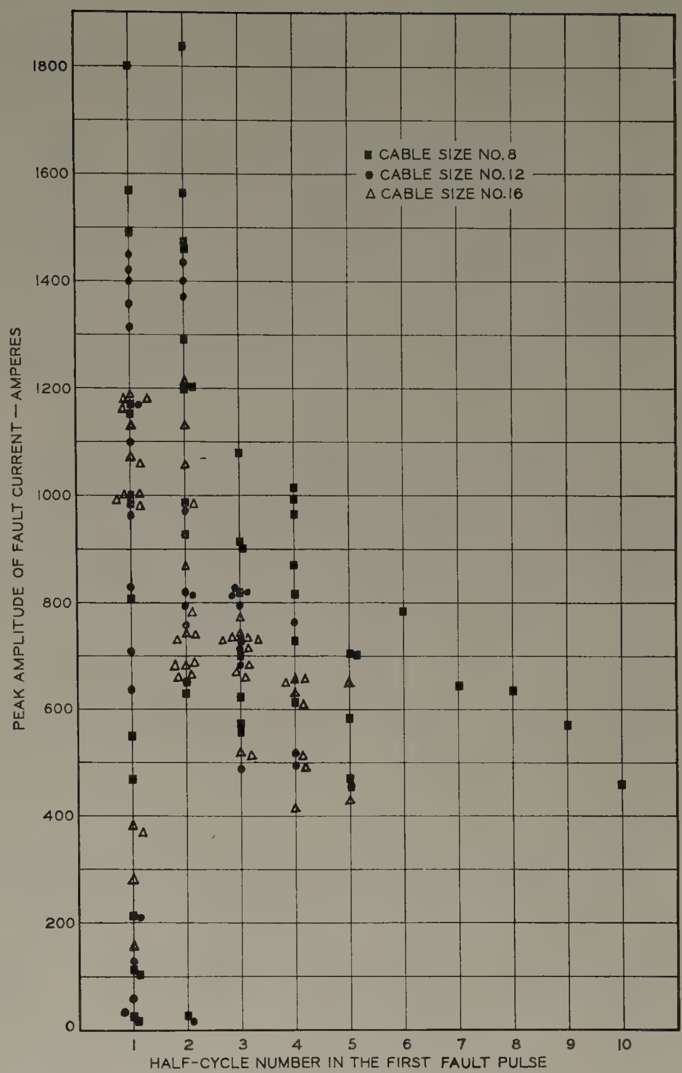


**Figure 7. Peak fault current versus half-cycle number in the first fault pulse for various cable sizes. Structure-vibration frequency 50 cycles per second, displacement 0.05 inch. Faults were established in a 120/208-volt 400-cycle system**

**Table II. Minimum Currents of 100 Per Cent and 75 Per Cent of the Intermittent Faults Occurring on a Simulated 30-Volt D-C Aircraft Electric System**

*Faulted Cables Are 5 Feet Long*

| Cable Size (Number) | Faults Established for Each Cable Size (Per Cent) | Average Current Due to Several Fault Pulses (Amperes) | First Fault Pulse: Average Current (Amperes) | First Fault Pulse: Duration (Seconds) |
|---|---|---|---|---|
| 16 | 100 | 5 | 50 | 0.005 |
| 16 | 75 | 25 | 100 | 0.01 |
| 8 | 100 | 5 | 50 | 0.005 |
| 8 | 75 | 75 | 300 | 0.01 |
| 2 | 100 | 5 | 50 | 0.005 |
| 2 | 75 | 100 | 400 | 0.01 |

Table III. Minimum Currents of 100 Per Cent and 75 Per Cent of the Intermittent Faults Occurring on a Simulated 120-Volt D-C Aircraft Electric System

| Cable Size (Number) | Faults Established for Each Cable Size (Per Cent) | Average Current Due to Several Fault Pulses (Amperes) | First Fault Pulse | |
|---|---|---|---|---|
| | | | Average Current (Amperes) | Duration (Seconds) |
| 16 | 100 | 5 | 200 | 0.01 |
| 16 | 75 | 50 | 300 | 0.01 |
| 8 | 100 | 5 | 200 | 0.01 |
| 8 | 75 | 115 | 400 | 0.02 |
| 2 | 100 | 10 | 300 | 0.01 |
| 2 | 75 | 115 | 400 | 0.02 |

of several pulses, the average fault current is calculated to be 50 amperes. Similar data were obtained for cable sizes number 8 and number 2, and the results are shown in Table III. Comparison of the values in Tables II and III shows that the 120-volt system does not give appreciably higher minimum fault currents than the 30-volt system.

Due to the extremely wide variation in magnitude of the first half-cycle of fault current in the a-c system, it was omitted from this analysis. The average duration of the first fault pulse was $2^1/_2$ cycles (0.0063 second). For single-phase faults on the particular generator used, the rms value of fault current is approximately 10 per cent less than the rms value of a sine wave of the same amplitude. It was further found that the average magnitude of current pulses following the first is the same as for the first pulse. The time between the first and second pulse of all the faults is 0.08 second or less, and the time between the first and second pulse of 75 per cent of the faults is 0.04 second or less.

With the foregoing interpretation, the rms current for each fault current pulse of all the faults struck on size number 8 cable is 150 amperes or greater. The minimum effective fault current, considered over the duration of several pulses, is calculated to be 10 amperes rms on size number 8 cable. The rms current for each fault current pulse of 75 per cent of the faults struck on size number 8 cable is 505 amperes or greater. The minimum effective fault current considered over the duration of several pulses for 75 per cent of the faults established is 70 amperes rms on size number 8 cable. Similar data obtained for cable sizes number 12 and number 16 are shown in Table IV.

## CONCLUSIONS

In most instances, when energized conductors are arbitrarily dropped onto an aluminum alloy plate connected to the system ground, the resulting faults are of the intermittent type. This condition exists while varying the parameters associated with the conductors, vibration, grounded structure, system load, and system voltage. Further, the minimum fault currents encountered are not changed when the system voltage is increased but depend upon the resistance of contact, as determined by the area of the contact, and the arc resistance. It was further found that the fault-current magnitude and duration of the first fault pulse is not markedly affected by vibration frequency, displacement, and direction, although fault duration increases when the faults are established on a vibrating platform.

There are two conditions under which welds occur. First, if there is sufficient contact pressure to prevent separation of the conductors of opposite polarity, and further, if there is sufficient circuit resistance to limit the current to a value lower than that necessary to melt the contact strands, the electrical fault will be of the welded type. Second, the conductor strands are heated during the drawing out of the first arc and the conductor and plate again make contact. Prior to the second separation, the contact areas cool and weld together provided that the circuit resistance is large enough to limit the current to a value lower than that necessary to melt the conductor strands in contact with the grounded plate.

Most intermittent faults start by fault current flow in excess of the current-carrying capacity of the contact strands. The contact strands become molten and part, causing an arc to be drawn out.

Damage to the grounded aluminum alloy structure is much greater from the faults established in the 120-volt d-c system. Further, damage to the aluminum alloy structure from light contact faults is greater for intermittent faults occurring in the 30-volt d-c system than for intermittent faults occurring in the 120/208-volt 400-cycle system. Although in this latter instance the arc is more severe in the a-c system, the arc duration is very short.

A fault-clearing device designed to clear all of the intermittent-type faults, and based upon the average fault current over several fault pulses, should clear a fault current of approximately 10 amperes. With present techniques in protection, however, this seems impractical. A fault-sensing device designed to clear a fault based upon the magnitude and duration of a single fault pulse appears to be more practical. A relay method of fault detecting and clearing, however, necessarily limits fault protection to a limited region of the aircraft. This is true because of the space and weight requirements for the numerous items required to protect each cable. In addition, it may be desirable in an emergency to permit faults on electric cables to vital equipment to exist until the emergency has passed or the vital equipment has failed.

If complete protection from ground faults is required, it is necessary to insure the electrical isolation of the wire conductors from the airplane structure. One suggested

Table IV. Minimum Currents of 100 Per Cent and 75 Per Cent of the Intermittent Faults (Based on Fault-Pulse Duration of 0.00625 Second) Occurring on a Simulated 120/208-Volt 400-Cycle Aircraft Electric System

| Cable Size (Number) | Faults Established for Each Cable Size (Per Cent) | Effective (RMS) Current Due to Several Fault Pulses (Amperes) | Effective (RMS) Current of First Fault Pulse (Amperes) |
|---|---|---|---|
| 8 | 100 | 10 | 150 |
| 8 | 75 | 70 | 505 |
| 12 | 100 | 15 | 200 |
| 12 | 75 | 60 | 460 |
| 16 | 100 | 5 | 70 |
| 16 | 75 | 55 | 390 |

method is to anodize the aluminum airplane structure. A study of this method has shown, however, that anodizing the surface affords adequate protection only so long as it remains unscratched. This surface insulation is relatively easily damaged and consequently is of little value as protection against electrical faults.

Another means of preventing the occurrence of some electrical faults consists of the installation of an ungrounded system monitored by a ground detector. This method, from a protection standpoint, would have merit if the possibility of simultaneous multiple grounds on cables of different polarity and line-to-line faults is disregarded.

Another means of gaining limited protection from faults is to provide cables able to withstand the conditions leading to a sustained intermittent fault. First, this requires a cable insulation which is fire resistant when heat is applied from the conductor side of the insulation. Second, cable insulation is needed which is secured to the conductor in such a manner as to expose a minimum of bare wire when the cable is parted. Third, an abrasion-resistant cable insulation is required.

It is recognized that isolating electrical faults can be accomplished in limited portions of the aircraft electric system. Further, with the present relaying techniques and aircraft-equipment requirements, a protection system should be committed to clear on the first fault pulse of an intermittent fault in order to minimize structural damage. For the large majority of wire footage, however, fault-preventive measures seem to be the most practical means to minimize fault damage in aircraft electric systems.


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# An Analysis of the Series Generator—Shunt Motor Oscillator


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ASSOCIATE MEMBER AIEE



**This unusual oscillator, composed of a series generator and shunt motor, is analyzed to illustrate the relationship between analysis and test. While having no immediately apparent application, this oscillator provides an interesting academic problem.**


IN THE COURSE of a University "Open House" exhibition at the University of Michigan, a self-excited series generator—shunt motor oscillator was demonstrated. This inspired some of the students to search the literature for a theoretical discussion of the rotating machine oscillator. When their search proved fruitless, this brief essay was prepared and some quantitative tests of the theory presented were made. These tests are submitted for what value they may have for other teachers and anyone else who might be interested in the subject of machinery system analysis.

The series generator—shunt motor combination may be represented schematically as shown in Figure 1. To carry out a mathematical analysis of this combination using simple differential equations, the following conditions were placed on the system:

1. The speed of the series generator drive motor is constant.
2. The series generator field strength varies linearly with current; there is no saturation.
3. The shunt motor field excitation is constant and there is no field reduction due to armature reaction.

These conditions permit a linear differential equation to

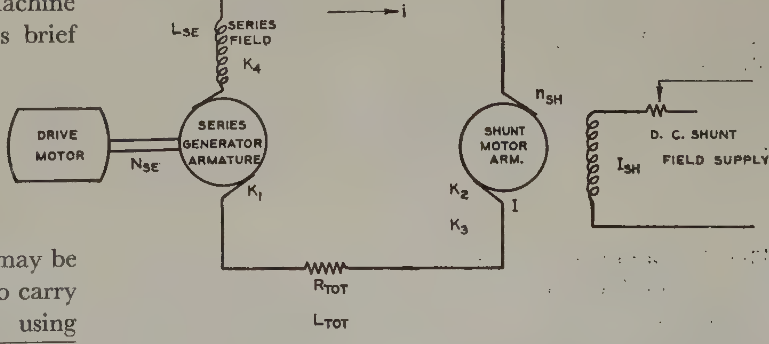


**Figure 1. Circuit of the series generator-shunt motor oscillator system**


Special article recommended by the AIEE Committee on Rotating Machinery.



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be written for the circuit loop containing the two armatures.

$$L_{tot}\frac{di}{dt}+K_2\phi_{sh}n_{sh}+iR_{tot}=K_1\phi_{se}N_{se} \tag{1}$$

where

$L_{tot}$ = total inductance of the loop
$\phi_{sh}$ = shunt motor flux, an adjustable ccontant
$n_{sh}$ = shunt motor rotational velocity in revolutions per second
$K_2$ = shunt armature generator constant
$R_{tot}$ = total resistance of the loop
$i$ = loop current
$\phi_{se}$ = series generator flux, proportional to $i$
$N_{se}$ = series generator rotational velocity in revolutions per second, an adjustable constant
$K_1$ = series generator armature constant

In addition, the following symbols are defined.

$I$ = motor armature moment of inertia
$K_3$ = shunt armature motor constant
$K_4$ = constant in $\phi_{se}=K_4i$

By use of auxiliary equations and the solution of equation

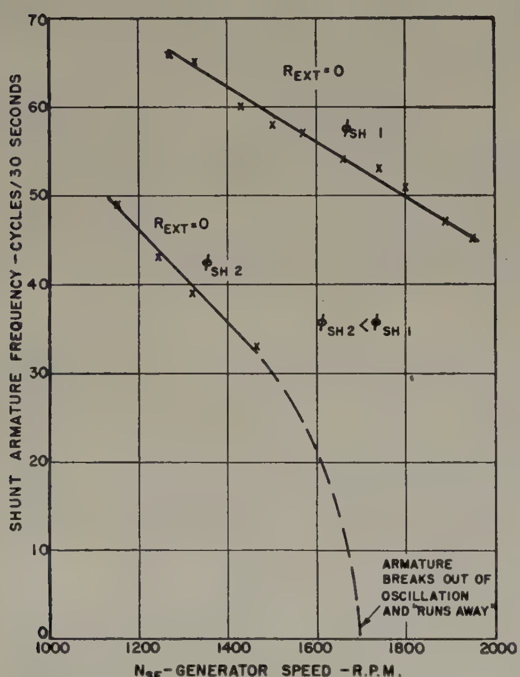


**Figure 2. Shunt oscillator frequency versus series generator speed**

1, the following expression for the shunt motor speed is obtained.

$$n_{sh}=C\epsilon^{-\left(\frac{R-K_1K_4N_{se}}{2L}\right)t}\epsilon^{+\sqrt{\left(\frac{R-K_1K_4N_{se}}{2L}\right)^2-\frac{K_2K_3\phi_{sh}^2}{2\pi IL}}\,t}+D\epsilon^{-(\quad)t}\epsilon^{-\sqrt{\quad}\,t} \tag{2}$$

The derivation of this equation and the details of $C$ are included in Appendix I.

Equation 2 is the usual solution for a second order linear differential equation with constant coefficients. However, the possible modes of operation indicated, as the parameters are changed, are of interest, and for one combination, distinctly unusual.

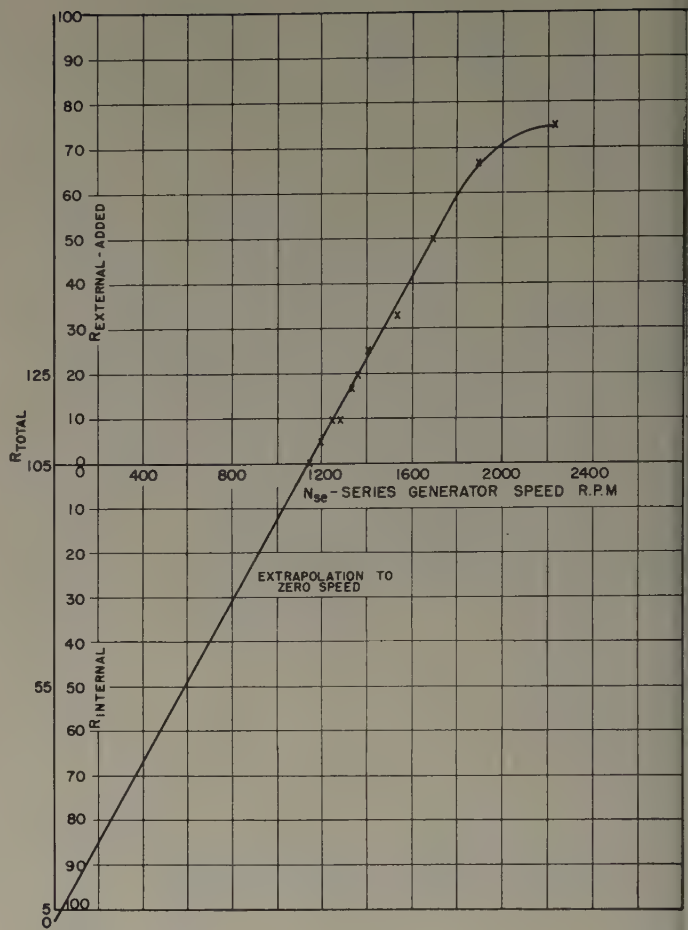


**Figure 3. Critical speed versus added external resistance**

Examining the operation of various parameter combinations

$$R>>K_1K_4N_{se};\quad \left(\frac{R-K_1K_4N_{se}}{2L}\right)^2>\frac{K_2K_3\phi_{sh}^2}{2\pi IL} \tag{3}$$

The system is overdamped and, if disturbed, will return to equilibrium with a unidirectional motion.

$$R>K_1K_4N_{se};\quad \left(\frac{R-K_1K_4N_{se}}{2L}\right)^2<\frac{K_2K_3\phi_{sh}^2}{2\pi IL} \tag{4}$$

Damped oscillations will occur if the system is disturbed.

$$R<K_1K_4N_{se};\quad \left(\frac{R-K_1K_4N_{se}}{2L}\right)^2<\frac{K_2K_3\phi_{sh}^2}{2\pi IL} \tag{5}$$

Undamped oscillations occur which grow in amplitude. In practice $L$ decreases due to saturation, limiting the oscillator swing.

$$R<<K_1K_4N_{se};\quad \left(\frac{R-K_1K_4N_{se}}{2L}\right)^2>\frac{K_2K_3\phi_{sh}^2}{2\pi IL} \tag{6}$$

No oscillation but an exponential increase in shunt motor velocity occurs.

Thus there is a range of parameters over which the series generator—shunt motor combination will oscillate. Below this range, the oscillations will be damped and the rotor

will come to rest. If the generator speed, $N_{se}$, is increased so that the conditions listed in equation 6 are satisfied, the system will break out of oscillation and run away. This continues until field saturation or commutator flashover due to excess voltage limits the process.

By using a drive motor—series generator combination with a nominal rating substantially greater than that of the shunt motor, all four modes of operation were demonstrated in the laboratory. The series generator was a 1-horsepower 220-volt series motor used as indicated and the shunt motor oscillator was a 1/8-horsepower machine.

This machine system, while it has no immediately apparent industrial application, is quite useful for illustrating the relationship between analysis and test and also demonstrates a mode of action very unusual among oscillators, that of breaking out of oscillation and accelerating indefinitely. Many unusual properties are displayed by this combination. Any residual magnetism in the series generator field will cause the generation of voltage and the resultant current will make the shunt armature crawl (equations 3 and 4). Any attempt to hold the shaft will lead to a current surge and acceleration of the motor. Releasing the shaft causes an abrupt halt and sometimes a reversal in crawl direction.

The most convenient method of frequency control is by means of the shunt field excitation. It would appear also that field control would permit frequency control without affecting the point at which damped oscillations occur as opposed to undamped operation. Actually, a stronger field introduces greater hysteresis and eddy current losses, effectively increasing $R$ and raising the minimum generator speed necessary for sustained oscillations.

Finally, the fourth mode of operation is most easily achieved if the shunt field is kept as weak as possible. However, armature reaction causes commutation difficulties which may confuse the picture somewhat.

The series generator—shunt motor oscillator is strongly recommended as an amusing yet highly instructive combination of machines for demonstration and teaching.

## Appendix I. Derivation of Equations

The equation for current, being simpler, will be derived first.

$$L_{\text{tot}}\frac{di}{dt}+K_2\phi_{sh}n_{sh}+iR_{\text{tot}}=K_1\phi_{se}N_{se} \tag{1}$$

The mechanical aspects of the problem, assuming the observation period starts at motor standstill, may be written

$$\omega_{sh}=2\pi n_{sh}=\int_0^t \frac{T_{sh}}{I}\,dt \tag{7}$$

where $T_{sh}$ is the torque developed by the shunt motor. Finally, establishing the relationship between electrical and mechanical aspects of the problem:

$$T_{sh}=K_3\phi_{sh}i \tag{8}$$

Substituting equation 8 in equation 7 and solving for $n_{sh}$

$$n_{sh}=\frac{K_3\phi_{sh}}{2\pi I}\int_0^t i\,dt \tag{9}$$

Substitute for $n_{sh}$ in equation 1 and using $\phi_{se}=K_4 i$,

$$K_1K_4N_{se}i=iR_{\text{tot}}+\frac{K_2K_3\phi_{sh}^2}{2\pi I}\int i\,dt+L_{\text{tot}}\frac{di}{dt} \tag{10}$$

This is a second order equation in one dependent and one independent variable. By differentiating and rearranging, a more familiar form is obtained

$$\frac{d^2i}{dt^2}+\left(\frac{R-K_1K_4N_{se}}{L}\right)\frac{di}{dt}+\frac{K_2K_3\phi_{sh}^2}{2\pi IL}t=0 \tag{11}$$

and, solving for $i$

$$i=A\epsilon^{\frac{R-K_1K_4N_{se}}{2L}t}\epsilon^{+\sqrt{m}t}+B\epsilon^{-\frac{R-K_1K_4N_{se}}{2L}t}\epsilon^{-\sqrt{m}t} \tag{12}$$

where

$$\sqrt{m}=\sqrt{\left(\frac{R-K_1K_4N_{se}}{2L}\right)^2-\frac{K_2K_3\phi_{sh}^2}{2\pi IL}}$$

A useful separation of parameter terms can be achieved from a study of the origin and dimension of the constants $K_1$ and $K_4$. This leads to

$$\frac{R-K_1K_4N_{se}}{2L}=\frac{R}{2L}-2N_{se}$$

To find the actual operating frequency $n_{sh}$, substitute $i$ as defined in equation 12 in equation 9.

$$n_{sh}=\frac{K_3\phi_{sh}}{2\pi I}\int_0^t A\epsilon^{-(p)t}\epsilon^{+\sqrt{m}t}dt+B\epsilon^{-(p)t}\epsilon^{-\sqrt{m}t}dt$$

where

$$p=\left(\frac{R-K_1K_4N_{se}}{2L}\right)$$

The result is as shown in equation 2 where

$$C=\frac{K_3\phi_{sh}}{2\pi I}\frac{1}{\sqrt{\left(\frac{R-K_1K_4N_{se}}{2L}\right)^2-\frac{K_2K_3\phi_{sh}^2}{2\pi I}}-\frac{R-K_1K_4N_{se}}{2L}}$$

and $D$ is similar.

## Appendix II. Experimental Results

For the most part, qualitative observations were made to study the four operational modes of the oscillator. However in addition, two quantitative measurements were made.

The first was a detailed study of the decrease in frequency with increase in generator speed, external loop resistance and shunt field excitation being kept constant. The results are shown in Figure 2. Two runs, one each for different values of $\phi_{sh}$ were made. In both cases, $R_{\text{added}}$ was zero.

The second test was a determination of the minimum values of $N_{se}$ for sustained oscillation, using different values of $R_{ext}$. It should be noted that, theoretically, oscillation is possible for very low values of $N_{se}$ provided $R$ is low enough. The high minimum value of $N_{se}$ for zero external resistance indicates that the effective internal resistance of the armature, due to hysteresis and eddy currents, is quite high. The data, when plotted as in Figure 3, can be extrapolated back to zero speed and zero total resistance. This determines the total resistance scale and the effective armature resistance can be found.

For the 1/8-horsepower motor the effective internal resistance was 105 ohms, but this, of course, depends on the field excitation. The change in slope of the curve is due to the saturation of the series generator field. For higher loop resistance, larger circulating currents are needed to maintain oscillation, and these larger currents cause a reduction in inductance through saturation.

# Tests on Transformers With Thermosiphon Oil Filters

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MEMBER AIEE

THE ELECTRICAL PROPERTIES of deteriorated insulating oils can be restored by pumping the oil through alumina or activated clays. Some transformer operators use this method to clean up old oil and others process their transformer oil in this manner.

In May 1943, a number of small transformers were placed on life test and several of them were equipped with a conditioner containing activated clay. This device consisted of a container filled with activated clay and piped into the transformer so that the oil flowed continuously through the clay by thermosiphon action resulting from the transformer loading cycle. At the end of 2 years, the benefits in oil maintenance due to the filter were so marked that it was decided to try it on full-sized power transformers.

Field tests were carried out in co-operation with a group of transformer operators. A filter containing about 75 pounds of activated clay was installed on each of 30 different transformers. They were chosen purposely to represent a wide variation in geographical location, size, quantity of oil, initial oil condition, and means of oil protection. Initial oil, measured on samples taken before installation of the filter, had dielectric strength from 16 to 39 kv, American Society for Testing Materials, oil power factor from 0.16 to 8.89 per cent, neutralization number from 0.01 to 0.61 milligram of potassium hydroxide, and interfacial tension from 11.8 to 39.0 dynes per centimeter. The only constant factor in the tests was the size of the filter.

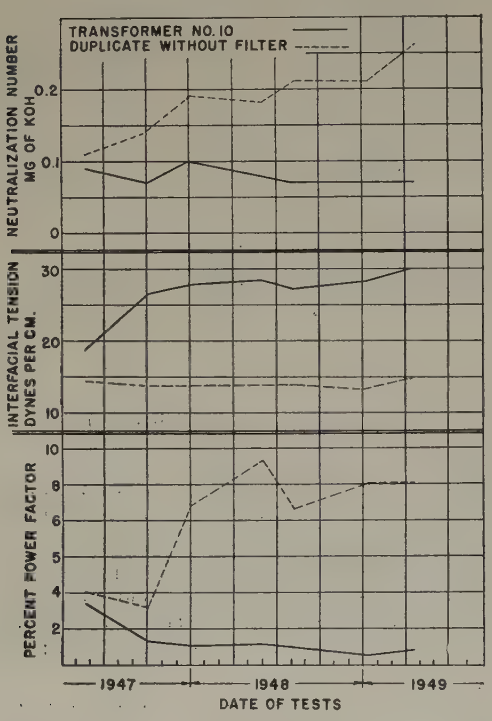


**Figure 1. Oil tests on transformer number 10**

A quart sample of oil was taken from the top and another from the bottom of each transformer at the time the filter was installed. Additional samples were taken at approximately 3- to 6-month intervals over the test period of from 2 to 3 years. All oil samples were sent to a central laboratory for tests. On each sample, measurements were made of dielectric strength, power factor, interfacial tension, total acids, water soluble acids, and union colorimeter index.

In Figure 1 are plotted the more important properties for one of the transformers. It is of special interest because each time an oil sample was taken from the test transformer another sample was taken from a duplicate transformer in the same bank which was not equipped with a filter. The data plotted on the curve are average figures for the top and bottom samples.

One interesting summary of the test results was made by comparing the initial oil at the start of the test with the oil after 2 to 3 years' operation with the filter. Compared in this manner, it was found that in 93 per cent of the transformers the oil dielectric strength had held constant or improved; in 93 per cent the interfacial tension values had increased; in 79 per cent the oil power factor had decreased; and 53 per cent showed the acidity or neutralization number had decreased. This record was made on transformers which contained, on the average, 2,680 gallons of oil. Many of the transformers were old and showed considerable oil deterioration at the time the filter was installed. Nevertheless, more than half of the transformers, after 2 to 3 years' additional service, had oil which showed improvement in all the important electrical properties.

These tests indicate that the thermosiphon filter is more effective in maintaining an initially low value of acidity than it is in restoring deteriorated oils. It is quite effective, even with as low a ratio of clay to oil as 75 pounds to 2,500 gallons, in increasing interfacial tension and decreasing oil power factor. One of the test transformers containing 11,580 gallons of oil increased in acidity from 0.06 to 0.18 in the first year after the filter was exhausted. In cleaning up old oil one figure of 0.91 pound of clay per gallon of oil to reduce the acidity from 0.50 to 0.13 has been given. On this basis, 3,120 pounds of clay would be required to cancel out the acidity increase. With 75 pounds of clay, the thermosiphon filter held the acidity constant for 2 years. A filter having 75 pounds of clay per 1,000 gallons of oil should have a life of from 5 to 15 years, depending on the load cycle.

Digest of paper 52-87, "Field Tests on Power Transformers Equipped With Thermosiphon Oil Filters," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Acknowledgement is made to W. W. Satterlee and J. G. Ford under whose direction the test program was carried out, and to Dr. T. K. Sloat who supervised testing of oil samples.

# Generator Lead Practice

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FELLOW AIEE

TO DETERMINE past and present practice for generator leads, a questionnaire was sent to utility and engineering companies requesting a description of the design and material used for each of their installations and their basic reasons for the type of installation chosen. They also were requested to cite any operating failures or difficulties and state whether the same design would be used again and, if not, why not. To avoid attempting to cover too much ground, the questionnaire was confined to generators having a rating of 20,000 kw or larger, installed in the past 10 years, or now being installed.

While the AIEE Insulated Conductors Committee activities cover insulated conductors, it was necessary to include bare conductors, as these often are used for generator leads. In many cases, the output of a generator is transmitted through a step-up transformer, the two forming a unit. For such an installation, generator leads are taken to mean the conductors from the generator terminals to the transformer.

No attempt has been made to compare costs of different types of installations, as such a comparison would be of no value due to wide differences in unit costs of material and labor over the past years, and also due to the greatly different conditions that affect design and installation.

The replies received covered 35 companies and 209 generators with a maximum continuous rating of approximately 16,700,000 kva, of which 76 generators with a rating of 7,529,000 kva now are being installed or are on order.

The voltage of the generators ranges from 11 kv to 18 kv. There are 179 rated between 11 kv and 14 kv inclusive, 13 at 14.4 kv, 5 at 15.5 kv, and 14 at 18 kv. The maximum continuous rating of the generators ranges from 23,529 kva to 202,000 kva, with an average of 79,000 kva. The corresponding current range is 1,000 amperes to 9,300 amperes. The higher figure is for a double-winding generator. The largest current reported for which leads were designed is 7,000 amperes.

For indoor leads the choice between insulated conductors and bare conductors is divided about equally. Varnished cambric or an oil base insulated cable appears to be preferred to other types of insulated conductors. One company uses varnished cambric insulation on its isolated-phase metal-enclosed leads. The number and size of insulated cables per phase vary from one 2,000,000- or two 1,000,000-circular-mil leads for 1,050 amperes, to three 3,500,000-circular-mil leads for 3,400 amperes. One company uses forced ventilation with filters for the tunnels in which are located insulated cable leads on insulators. With bare conductors, some type of metal enclosure appears to be used in the majority of the installations. The amount of copper per phase varies from 3.8 pounds per foot for 1,000 amperes to 50 pounds per foot for 6,500 amperes. Although not shown in the chart, isolated-phase metal-enclosed leads appear to be the most popular for generators rated over 60,000 kw, copper bar, channels, angles, pipe, and square hollow tubing being used.

For outdoor leads 63 per cent of installations have bare conductors and 37 per cent insulated conductors. Paper-insulated lead-covered cables appear to be preferred to other types of insulated conductors. The number and size of the insulated cables vary from one 2,000,000-circular-mil leads per phase for 1,050 amperes, to four 4,000,000-circular-mil leads per phase for 4,650 amperes. With bare conductors, 59 of the installations have complete enclosures, 21 are protected by screens, and 25 have no enclosures. Of the 105 installations, 67 have barriers between phases. One installation uses aluminum angles for leads. The same remarks which apply to indoor practice apply to outdoor practice with respect to isolated-phase metal-enclosed leads.

The following range in mils was given for insulation thickness on single-conductor cable for 13.8 kv:

| | Range | Prevailing |
|---|---|---|
| Paper | 203–329 | 250 |
| Oil base | 422–438 | 422 |
| Varnished cambric | 328–438 | 328 |

Segmental, compact segmental, and annular cables appear to be the preferred stranding. Concentric stranding appears to be the least used. The lead-sheath of single-conductor cable in most cases is grounded at one end only. In two cases it is grounded at the center of the run.

In the case of 157 installations, it was stated that the design would be repeated for new work. In nine cases where insulated cable, and one case where segregated-phase metal-enclosed is used, it was stated that the design would not be repeated. In three installations where insulated cable was used, it was stated that for similar conditions on new work isolated-phase metal-enclosed leads would be preferred.

Most economical design for the required reliability appears to be the basic reason for most installations. In many cases, however, other factors, such as space limitations, had an effect on the type of installation adopted.

In the case of 134 installations, trouble was experienced with 25, of which 15 were insulated cable and ten were with bare conductors. There were nine failures of varnished-cambric insulated cable, and six cases of pothead leakage, two of which were of the gas type. In the case of metal-enclosed leads, one case of moisture and nine cases of heating greater than specified were reported.

**Digest of paper 52-93**, "Generator Lead Practice," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Not scheduled for publication in AIEE *Transactions*.

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# A New Permanent-Magnet Material of Nonstrategic Material

F. G. BROCKMAN

**Cobalt and nickel shortages highlight the introduction of this permanent-magnet material which uses no strategic materials. Magnets composed of it display a high coercive force and excellent resistance to demagnetization.**

THE WIDESPREAD use of permanent magnets and the present shortages of cobalt and nickel, which are used in many of the permanent-magnet materials, makes the advent of a new permanent-magnet material which does not require these, or other, strategic materials an occurrence of singular importance. Such a new permanent-magnet material is described here. This material has been developed in the Eindhoven, Holland, laboratories of the Philips Company, the same laboratories from which the important developments in ferrites were announced in 1947.[1] Like the ferrites, this new material is nonmetallic but it is a permanent-magnet material while the ferrites developed by Philips are magnetically soft. The workers in the Eindhoven laboratories associated with the development are Went, Rathenau, Gorter, and van Oosterhaut.[2]

## THE CHEMICAL NATURE OF THE MATERIAL

THE MATERIAL which has come into commercial production is composed essentially of a compound having the formula $BaO \cdot 6Fe_2O_3$, which also may be written $BaFe_{12}O_{19}$. This compound is analogous to the compound magnetoplumbite, $PbFe_{12}O_{19}$, and a third compound of the series is the strontium analogue, $SrFe_{12}O_{19}$. All three possess similar magnetic properties but the barium compound is the practical and economical choice for commercial applications. These three compounds crystallize in the same system and the structure is hexagonal. The model, reproduced in Figure 1, has been patterned after Adelskold's[3] description of the structure. This model shows the arrangement of the ions within the unit cell, the larger white spheres represent oxygen ions, the large dark ones barium, and the smaller spheres represent the ferric iron ions. The unit cell is the smallest aggregate of ions in a crystal which is characteristic of the crystal. The base of this unit cell is 4-sided with equal lengths to each side. Two opposite angles are 60 degrees and the other two are 120 degrees. If three of these units are placed side by side, each pair sharing one side, then the hexagonal character of the crystal becomes apparent. See Figure 2.

The material is made by reacting at high temperatures solid oxides in the proper proportions. This reaction is carried out in a manner similar to the methods[1] used in the manufacture of the ferrites, and the product is a ceramic-like material with mechanical properties much like the ferrites. It is hard, and reasonably strong, is shaped principally by pressing the desired shape before firing, and can be machined after firing by grinding. This material is mechanically superior to the commercial varieties of the cobalt ferrite-ferrous ferrite nonmetallic permanent-magnet material described by Kato and Takei[4] in 1933.

## THE PROPERTIES OF THE MATERIAL

THE MAGNETIC properties which are of practical interest for permanent-magnet materials are the coercive force, $H_c$, the remanence, $B_r$, the product of these two factors, $H_c \times B_r$, and the maximum energy product $BH_{max}$.

Figure 3 is a hysteresis loop for a sample of this material. These technically important quantities are to be found in the second quadrant of this graph, and this portion of the loop, called the "demagnetization curve," together with a plot of the product of $B$ and $H$ as a function of the induction, is reproduced on a larger scale in Figure 4. From Figure 4 the following properties can be determined:

Coercive force, $H_c$ ............... 1,500 oersteds
Remanence, $B_r$ ................. 2,000 gausses
Product $H_c \times B_r$ ................ $3 \times 10^6$ gauss-oersteds
Maximum energy product, $BH_{max}$ .. $0.8 \times 10^6$ gauss-oersteds

Also in Figure 4 is given the intrinsic demagnetization curve, that is, the variation of $B-H$ (which equals $4\pi I$) with the field, $H$. The intrinsic coercive force of this material is about 2,900 oersteds. Both coercive forces, $H_c$ and the intrinsic coercive force, are unusually high for commercial permanent-magnet materials.

The character of the demagnetization curve also is unusual. The curve of $B$ against $H$ is substantially linear and the slope is not greatly different from unity. This means that both the differential permeability and the incremental permeability in this region are not much larger than unity. Indeed, experimental investigations of minor hysteresis loops in this region yield minor loops which lie almost on top of the demagnetization curve itself.

A demagnetization curve of this character indicates a high order of stability for permanent magnets of this material. A magnet of this material can be magnetized externally to the magnetic circuit in which it is to be used, and inserted into the circuit without serious loss in the

Full text of a conference paper recommended by the Subcommittee on Magnetics of the AIEE Committee on Basic Sciences and presented at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

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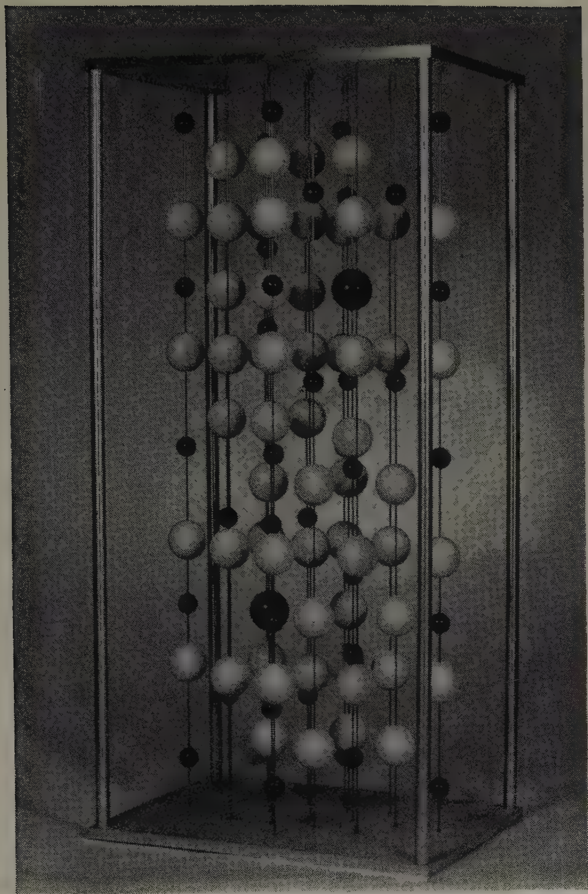

**Figure 1. Model of the crystal unit cell of the essential compound in the new material, $BaO \cdot 6Fe_2O_3$**

induction. This can be an important consideration in certain applications.

Two other magnetic characteristics which should be mentioned at this point are: Curie point=450 degrees centigrade; and saturation induction at room temperature, $B_s(=4\pi I_s)$ approximately 4,000 gausses, with $I_s$ approximately 320.

## THE MAGNETIC NATURE OF THE MATERIAL

If the saturation magnetization is obtained as a function of temperature and then extrapolated to absolute zero it is possible to estimate the number of Bohr magnetons per molecule (in a ferromagnetic compound, or per atom in a ferromagnetic element). The saturation magnetic moment per gram at absolute zero for this material is approximately 100.

Using the relationship

$$n_0 = \frac{\sigma_0 \times MW}{\mu_B \times \mathcal{N}_0}$$

the number, $n_0$, of Bohr magnetons per molecule can be calculated from the saturation moment per gram at absolute zero, $\sigma_0$; the molecular weight of the compound, $MW$, here $BaFe_{12}O_{19}$, is 1,110; the number of molecules per mole (Avogadro's number), $\mathcal{N}_0 = 6 \times 10^{23}$; and the numerical value of the Bohr magneton, $\mu_B = 9.3 \times 10^{-21}$ gauss-cubic-centimeter.

This yields 20 as the number of Bohr magnetons per molecule. There are 12 ferric ions in each molecule, each ion possessing 5 Bohr magnetons, or, if all spins were aligned, a total of $12 \times 5$ or 60. This indicates that in this compound not all spins are aligned and that probably the same kind of indirect exchange (or "superexchange") exists here as in the ferrites, with an uncompensated antiferromagnetism of the type used by Néel[5,6] to explain the ferromagnetic behavior of the ferrites. Indeed, Gorter has succeeded in obtaining a quantitative agreement with the 20 Bohr magnetons by assuming that negative interactions occur between iron ions across oxygen bridges for those pairs in which the angles between iron ions

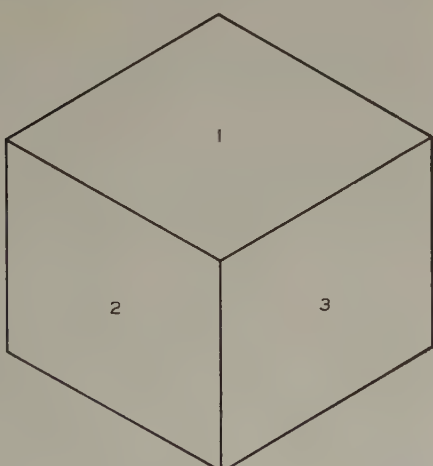


**Figure 2. Arrangement of the bases of three unit cells of $BaO \cdot 6Fe_2O_3$ illustrating the hexagonal character of the crystal**

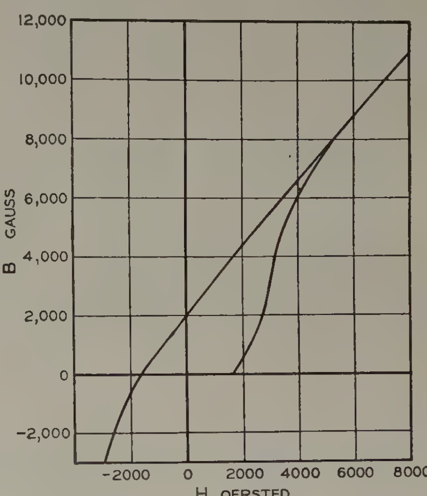


**Figure 3. Hysteresis loop of a sample of the new material**

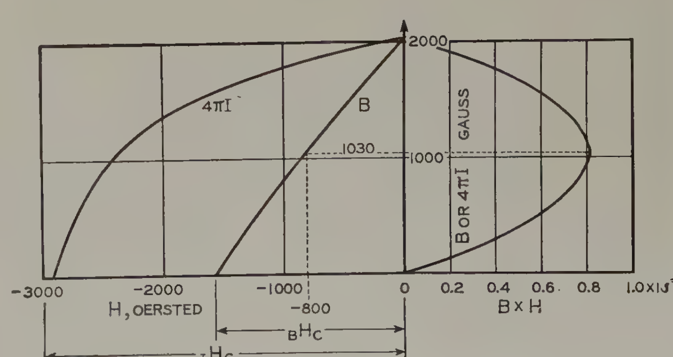


**Figure 4. Demagnetization curve and BxH product of a sample of the new material**

through the oxygen are nearest to 180 degrees. This assumption is based on the theoretical consideration of superexchange due to Anderson.[7]

The foregoing discussion accounts for the saturation magnetization of this material but the explanation of the unusual properties displayed in the demagnetization curve, especially the high coercive force, must be found in another manner.

Two factors appear to be responsible for the high coercive force. The first is the large magnetic crystalline anisotrophy. The fact that this substance crystallizes in the hexagonal system with the large ratio of the crystal axes of 5.9 to 23 (which is readily evident from the model illustrated in Figure 1) indicates that, aside from its magnetic properties, a high degree of anisotropy exists. It is not surprising, therefore, that a high order of magnetic crystal anisotropy thus is to be found in this type of material.

The magnetic crystal anisotropy has been measured[2] and it has been found that the easy direction of magnetization is the direction of the hexagonal axis. There appears to be no preferred direction in the basal plane (that is, in a plane at 90 degrees to the hexagonal axis). The energy (per cubic centimeter) necessary to turn the magnetization from the direction of easy magnetization can be represented by the series

$$E_k = \Sigma_n K_n \sin^{2n}\theta$$

where $\theta$ is the angle through which the magnetization is turned against the anisotropy forces and the $K$'s are constants of the material. It is often the case that a

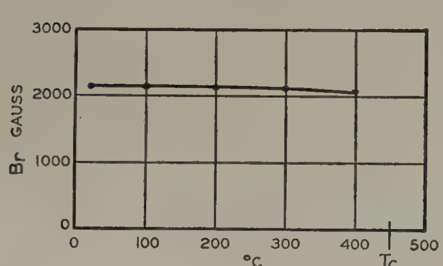


**Figure 5. Illustration of high resistance to demagnetization. Effect of temperature upon the remanent induction**

sufficiently accurate representation of this energy is given by only the first term of the series and the expression is written

$$E_k = K \sin^2 \theta$$

The value of the constant $K$ at room temperature has been found to be $3 \times 10^6$ ergs per cubic centimeter.

The second factor associated with the high coercive force is one related to the subject of fine powder magnets. Bozorth[8] in 1949 considered this subject among the then contemporary advances in magnetic theory. The principles underlying the powder permanent magnets which will be useful here are: 1. when a particle of a ferromagnetic substance is small enough it may exist as a single domain because the energy associated with a magnetic dipole of small size may be less than the energy required to form domain boundaries; 2. when single domain particles exist, a change in the direction of the magnetization must occur against the magnetocrystalline anisotropy force; and, 3. because, compared with the energy required to move a domain boundary, the energy required to act against the anisotropy is great, large coercive forces are possible.

Although this material is produced by a sintering technique, the permanent-magnet properties described are developed only when the processing is accomplished so that crystallite growth is inhibited. If, for instance, crystal growth is permitted to take place, the coercive force is quite small. But if this coarse-grained material is pulverized, the coercive force increases. Thus in a particular coarse-grained sample the intrinsic coercive force, ${}_iH_c$, was 50 oersteds, but when this material was ground until the particle sizes averaged 3 microns, the intrinsic coercive force rose to 1,240 oersteds. Thus the large coercive force is found to be related to the particle sizes.

The model used by Bozorth in his 1949 paper[8] may be used to compare the particle sizes of this new product and of iron below which single domain particles occur. This may be done under the assumption that theories developed concerning domain boundary energies for ferromagnetic materials apply as well to materials which have ferromagnetic behavior because of uncompensated antiferromagnetism.

A further assumption also must be made that the spacing between ferromagnetic ions in the lattice can be specified. This is necessary so that the energy per square centimeter of a domain wall can be evaluated. When all these liberties have been taken one can estimate that particles of this material which may exist as single domains are roughly 40 times larger than those of iron. Iron particles about 200 Angstroms in diameter have the high coercive force associated with particles of the nature under discussion. Forty times this size is 8,000 Angstroms or 0.8 micron, not too bad an agreement with the 3-micron figure in the experimental example.

Qualitatively, the high coercive force of this material can be understood on the basis of fine particle theory. In Bozorth's paper[8] it was pointed out that the coercive force for a fine particle will be about $2K/I_s$. Application of this factor to determine the coercive force of this substance leads to a value considerably greater than those obtained in practice. This is not surprising in the light of the work done with fine metal powders. There the coercive force increases rather gradually as the particle size is decreased. Kittel[9] has considered this situation theoretically on the basis that, although a single particle may exist as a single domain, the application of an external field (opposing the magnetization of the particle) in excess of some limiting field will cause the appearance of a domain wall in the particle. From this field on to higher fields, then, the magnetization can proceed by boundary displacement. The larger the particle which is initially a single domain, the smaller will be the opposing external field necessary to bring about the growth of the domain wall. Kittel has the following expressions from his derivations:

$$H_c^{\infty} = \frac{2K}{I_s}$$

$$<H_c^\infty>_{AV}=0.64\ \frac{K}{I_s}$$

where $H_c^\infty$ is the maximum numerical value of the coercive force to be expected from a single domain particle of anisotropy constant $K$ and saturation magnetization $I_s$, and $<H_c^\infty>_{AV}$ is the maximum average value of the coercive force for crystallites oriented at random.

The maximum value of the average coercive force for this material is calculated to be

$$<H_c^\infty>=\frac{0.64\times3\times10^6}{3.3\times10^2}=5{,}800$$

In addition Kittel derives the diameter, $D$, of a (spherical) particle at which the coercive force is reduced to 1/2 of its maximum value

$$D=\frac{12\sigma}{I_s^2}$$

where $\sigma$ is the energy per square centimeter of a Bloch wall and this is approximately $(KkT_c/a)^{1/2}$, where $k$ is the Boltzmann constant, $1.4\times10^{-16}$ erg per degree; $T_c$ is the Curie temperature in degrees absolute and $a$ is the atomic separation.

Using the constants known for this material and making the same assumptions made previously in considering the particle sizes

$\sigma\sim3$ ergs per square centimeter

and with $I_s=330$ gausses, $D$ is found to be

$$\frac{12\times3}{330^2}\approx3.3\times10^{-4}\ \text{centimeter}=3.3\mu$$

That is, when the particles are about 3 microns in diameter, the coercive force should be about 5,800/2 or 2,900 oersteds, a value which is not very different for the highest values observed.

The remanence of an unoriented polycrystalline material should be half the saturation magnetization.[10] This is true with this material, the remanence being about 2,000 gausses, and the saturation about 4,000 gausses.

## APPLICATIONS

In considering the application of this new permanent-magnet material perhaps the most important characteristics which will recommend its use are the high coercive force and the nearly unity slope of the demagnetization curve. Both of these properties indicate a high stability of the material to demagnetizing influences. Magnets made of this substance can be magnetized externally to the circuit in which they will be used and then be introduced into that circuit without appreciable reduction in the induction. Because of this feature certain magnetic circuit designs may be possible which otherwise would be impractical.

The high resistance to demagnetization which is characteristic of this material is illustrated in Figures 5 and 6. Figure 5 shows graphically what happens to a magnet of the material which has been magnetized and then heated to some higher temperature and cooled to room temperature. When so treated, the remanence returns to its initial value even when the temperature to which it was raised is 400 degrees centigrade. The Curie temperature is indicated on the figure. Figure 6 shows the effect upon the remanent magnetism in a magnetized piece of the material after insertion into and removal from a demagnetizing field of various strengths. Note that up to a field of about 1,600 oersteds the remanence is constant to about 1 per cent.

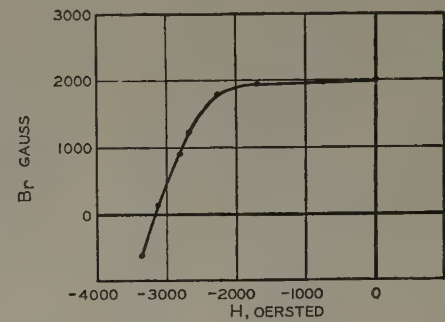


**Figure 6. Illustration of high resistance to demagnetization. Effect of opposing fields upon the remanent induction**

This resistance to demagnetization recommends the material for use in applications, such as motors and generators, in which the air gap (and hence the demagnetizing field) is frequently altered.

The high specific resistance makes it possible to use this material in high-frequency fields and it has been used in such applications to supply biasing fields.

While the energy product of this material is low compared with the 4.5 or more obtainable with Alnico V, it is expected that it will find fields of usefulness not only because of its unusual properties, but also because of its specific gravity advantage. The specific gravity of the material is about 4.5 compared with about 7.5 for most magnet steels. Indeed, in the Eindhoven, Holland, factories of the Philips Company, this material is replacing Alnico V in loudspeaker construction. Manufacture for this purpose was initiated in the middle of 1951 and with increased facilities it is expected that 80 per cent of the loudspeakers manufactured there in 1952 will use this material for the field magnet.

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# New Wind Tunnel Drive Control

G. T. STRAILMAN
MEMBER AIEE

**With the advent of modern transonic and supersonic aircraft speeds, the size and complexity of wind tunnels to develop designs and evaluate performance has increased enormously. A change in the conventional Kraemer type of control system is presented as a possible solution to the current need.**

VARIOUS TYPES of control for large wind power drives have been built and successfully operated by educational institutions, manufacturers, and government research organizations engaged in aeronautical research. In general, electrical engineering practice has kept abreast of rapidly expanding requirements of size and types of air-moving equipment such as propellers, compressors, and blowers.

In early wind tunnel practice, horsepowers involved were very low as compared to present-day practices. Several hundred horsepower usually sufficed for the majority of tunnels. With horsepowers of this order, the necessary range of control and accuracy could be readily achieved with Ward-Leonard d-c drives. Practically all such tunnels, including the pressure or variable density types, could be operated satisfactorily with conventional multiblade propellers. Air speeds involved were usually very much lower than the velocity of sound and corresponded to the air speeds of contemporary aircraft or at least to proposed or contemplated air speeds. Power supply for such tunnels presented no serious problems, as the power required was a small percentage of the capacity of a moderate size public utility system.

With the advent of modern transonic and supersonic aircraft speeds, the size and complexity of tunnels required to develop designs and evaluate performance before and after production has increased enormously. Power demands have increased to the point where the planning of a major tunnel facility involves major additions to the power system or selection of a site for the tunnel in the proximity of large power centers.

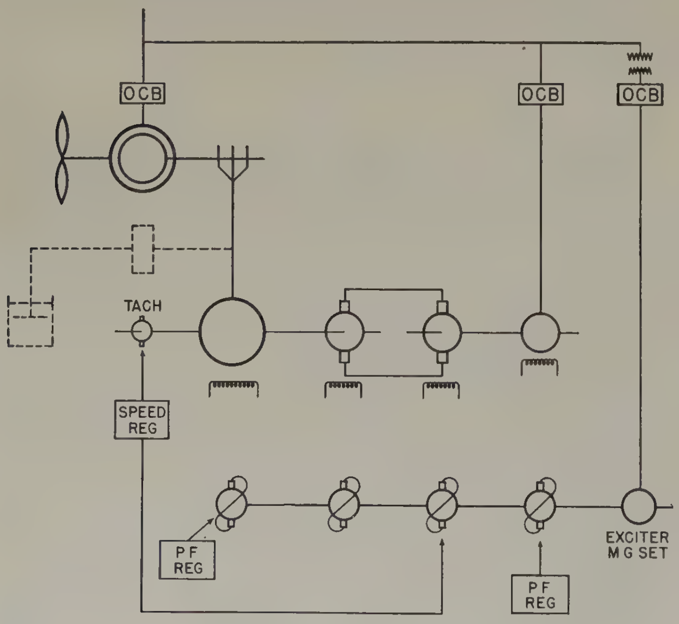


**Figure 1. Kraemer wind tunnel drive with the addition of a liquid rheostat as shown by broken lines**

Facilities are now being built with more than 200,000 horsepower in a single tunnel. Adjustable speed tunnel drives are now in operation requiring 60,000 horsepower or more. With power of this magnitude, the demand of the unit may be a large proportion of the local capacity of even a moderately large utility system, and in some instances, may tax the generation and transmission facilities of the power supply system.

This has required the selection of a type of motor and control to achieve stability and enable magnetizing, starting, and speed control without impairing the service to public utility customers.

The current solution of the problem of wide range speed control with acceptable disturbance to the power supply system is the use of the Kraemer wind tunnel drive* as shown by Figure 1. In this system, the wound-rotor induction motor or motors are magnetized from the secondary or rotor, and the slip is controlled by an adjustable-frequency synchronous machine connected to the rotor, which delivers the slip power to a Ward-Leonard loop and thence back to the line through a synchronous machine. The speed of the wound-rotor motor is controlled by changing the speed of the adjustable-frequency machine by means of the Ward-Leonard loop generator voltage and motor field control.

Magnetizing current and power factor are controlled by a regulator in the field of the adjustable-frequency machine. This arrangement is unfavorable because the inherent slot space of rotor-to-slot space of stator ratio in the usual slip-ring motor allows proportionally more copper in the stator. The magnetizing current is imposed on the rotor copper rather than the stator copper where it can be tolerated. If the usual order of things could be reversed, with the rotor made the primary and the stator becoming the secondary, the disproportion could be corrected, but additional problems of subdividing the centrifugally stressed rotor copper against eddy current losses would be present. To the writer's knowledge, this has not been attempted in wind

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* The Kraemer drive described has been called "Modified Kraemer" by others. It is true that the Kraemer patent describes a convertor for energy recovery, but other types of energy recovery and return to the power supply system are claimed also. Therefore, it is felt the Kraemer patent is broad enough in scope to not warrant the use of the term "Modified."

tunnel practice and would seem to offer distinct advantages in eliminating rotor copper overheating which has been observed in some existing tunnel drives with Kraemer control. This is mentioned because there is an economical limit to power factor correction by rotor magnetization.

The Kraemer drive is started by first starting the constant-speed motor-generator set. This set is usually in the order of 20 per cent of the drive motor rating as indicated by the slip power curve of Figure 2. Large drives require the use of several d-c machines to make up the required capacity for economical reasons, and these are usually connected to a single constant-speed synchronous motor. A set of this kind is started by using one of the d-c excitation motor-generator sets to supply power to the d-c machines for starting and synchronizing purposes.

After the constant speed set is brought up to speed and synchronized, excitation is applied to the adjustable-frequency machine and its speed and frequency raised at a rate suitable to the power system. The wound-rotor motor is thus gradually magnetized, and its primary synchronized and connected to the line without a high magnetizing inrush. Since the power factor is under regulator control, there are no kilovolt-ampere swings to impair performance.

After synchronization, the drive motor is at a standstill. It may be started by reducing the frequency of the adjustable-frequency machine to a slip frequency corresponding to the desired drive motor speed. The speed range is from zero to approximately 92 per cent synchronism with economically proportioned drives.

The efficiency of a drive of the afore-described type is high, but the increased cost over that of a plain liquid rheostat control is also very high; it never can be amortized by the slip power recovered and delivered to the line in view of the short life and early obsolescence of wind tunnel drives and the relatively low load factor practicable in research testing. It is the purpose of this article to deal with a method of reducing the first cost of the type of drive described at the expense of some operating efficiency while retaining all other advantages of the conventional Kraemer control.

Kraemer drives, prior to the successful application of the hereinafter described system, required the d-c machines and the constant-speed synchronous motor to be of a size adequate to handle the slip power of the wound-rotor motor. By connecting a liquid rheostat to the rotor terminals of the wound-rotor motor as shown by broken lines in Figure 1, the size of these machines may be reduced to the value required to handle the forcing power to regulate the speed. The magnitude of this power will depend, of course, on the amplitude of system voltage and frequency swings.

Frequency stability on most interconnected power systems is very good and should present no problem. Voltage swings must be compensated for by the forcing ability of the d-c loop machines.

By proper co-ordination of the liquid rheostat control with fast response control on the d-c loop voltage, the loop machines can be made to correct speed deviations from the control setting and carry the power required to do so until the relatively slow moving rheostat assumes the change in load while the automatic fast response control backs off. This leaves the d-c machines unloaded with appreciable slip

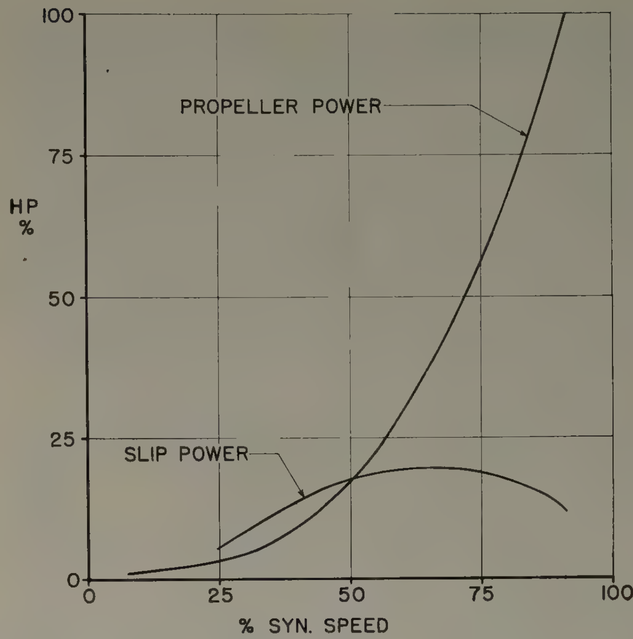


**Figure 2. Relationship of speed, propeller power, and slip power in the Kraemer drive**

power. For this duty, the d-c machines may be subjected to momentary or short-time loads well above their continuous rating.

Some power recovery may be effected depending on whether the capacity of the d-c machines is needed for speed correction. With a well-regulated system the energy recovery can be higher than with a poorly regulated system. Conversely, good voltage regulation of the power supply permits the use of smaller d-c machinery capable of little or no power recovery.

The adjustable-frequency machine should be capable of magnetizing and supplying corrective reactive kilovolt-amperes to maintain the power factor of the drive at the desired level. This is commonly fixed by economy of power and physical limitations of the power system in respect to tolerable lagging reactive. Some margin of reactive kilovolt-ampere capacity also may be provided to correct, or partially correct, the power factor at the primary side of power transformers supplying the drive. The limitation of this function may be found in the wound-motor rotor copper as already explained. The synchronous motor of the constant speed set also may be used to correct power factor. It is desirable to use power factor regulators on both machines to obtain automatic adjustment over a wide speed range.

It is not within the scope of this article to deal with the performance of various types of electronic and rotary amplifier regulating devices. It is sufficient to say that these devices are considered very desirable and effective in relieving the operators of the duty of frequently adjusting fields as speed is changed. Furthermore, good performance has been achieved in automatic current, voltage, and speed limiting circuits incorporated in the electronic regulating equipment.

With the conventional Kraemer control, the economical limit of speed at the wound-rotor motor is approximately 92 per cent of synchronism. Higher speeds would require

much larger and "stiffer" machines to maintain a satisfactory level of stability.

With the addition of a liquid rheostat to the rotor circuit as described, the maximum speed may be raised to the order of 95 per cent synchronism by proper co-ordination of machine characteristics.

The practicability and economy of the rheostat addition for increasing existing tunnel performance has been demonstrated recently at the Langley Aeronautical Laboratory of the National Advisory Committee for Aeronautics at Langley Field, Va. A Kraemer drive especially designed for operation at 465 rpm at 12,000 horsepower was boosted to 490 rpm and 14,000 horsepower by the addition of a liquid rheostat. In this case, both speed and torque were increased as it was possible to increase the cooling air through the motor to offset the increase in motor losses.

Whether to use a circuit breaker to disconnect the liquid rheostat during starting is determined by over-all economy in its cost as compared to the d-c machine capacity to supply the rheostat losses during gradual magnetization of the motor, when synchronizing and when accelerating after the primary is connected to the line.

# Maintenance and Operating Experience With Diesel-Electric Locomotives

C. H. GRIFFITH E. H. PFEIL
APPLICATION PENDING

**Four different makes of locomotive, totalling 197 units operating on over 3,000 miles of railroad, furnish the basis of this report on troubles encountered in diesel-electric operation.**

WITH ONE GROUP of 21 road freight diesel-electric locomotive units starting service in June and July, 1947, a marked pattern of commutator bar discoloration followed by bar etching and flat spots appeared which necessitated the resurfacing of the commutators on all units. This trouble developed when locomotives had been in service 5 to 6 months and had operated approximately 80,000 miles. It is believed that it was caused by the improper functioning of automatic transition and possibly aggravated by commutator eccentricity.

Since the commutators were resurfaced and automatic transition modified so as to eliminate the cycling between series-parallel shunt and parallel motor connections, no similar trouble has been experienced, the commutators now being in excellent condition after more than 700,000 miles of operation. Another modification made on these units was a change from closed-circuit to open-circuit transition. At the same time current values for controlling backward transition were increased approximately 500 amperes, thereby reducing the number of motor connection transfers. These changes are believed to be an aid in the elimination of commutator trouble.

On another group of 18 road freight units placed in service from November 1948 to March 1949, considerable trouble was experienced in maintaining commutator surface due to threading and copper drag which tended to produce flashovers. These generators had commutators of the open-riser type which were difficult to keep clean principally because the air drawn through the generator by the generator blower was laden with oily vapor collected in the air stream in passing over the top of the engine. These oily vapors made it difficult to keep the front and rear V-ring string bands clean, thereby producing a condition which was contributory to flashovers.

These conditions have been improved by changing the grade of brush, reducing the number of brushes per holder to obtain greater current density, and by the blocking of some car body filters to change the air flow pattern in the engine room. In this case the first two changes mentioned contributed most to relieving the trouble.

On a third group of 20 road freight units placed in service during July 1949, quite a few flashovers occurred which were attributed principally to oily vapors being blown through the main generator and collecting on brush holder insulators. These oily surfaces collect carbon dust and thereby furnish a path to ground. These particular units are of the same manufacture as the first group mentioned, but are of a later design and model. In the modernization of these units the manufacturer reduced the number of car body filters $33^1/_3$ per cent and applied louvres which gave the locomotive a much better external appearance. The filters eliminated were at a location in the end of the car body where the major portion of engine room air requirements are, namely, engine air, generator blower, front traction motor blowers, and air compressor. With the reduc-

Full text of paper 52-145, "Maintenance and Operating Experience—Diesel-Electric Locomotives," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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tion in the number of filters, the restricted air flow through the louvres, and the revision of filter location, it is evident that some of the generator blower air must be supplied from the air stream passing over the top deck of the engine.

One of these units recently had a fire in the main generator, a fire which might be classified a "trash" fire, as inspection disclosed the fact that the burning material was an accumulation of grease which evidently had been ignited by a severe flashover and fanned by the generator blower. Fortunately the damage was negligible, as a maintainer who was riding the locomotive took the unit off the line, shut the engine down, and extinguished the blaze with fire extinguishers. When the generator was removed and thoroughly cleaned with ground corn cobs, no serious damage was found, merely the burning of approximately 1 square inch of outer insulation on a compensating field connection.

These oil-laden vapors produce a gummy condition in the brush holders which in turn is apt to set up ring fire and eventually a flashover between brush holders of opposite polarity. To alleviate this a program of installing six additional standard car body filters in each unit located in the area of the maximum air demand has been initiated.

With this particular type of locomotive the main generators are operating at greater temperatures than those of the older type as a considerable quantity of air is being recirculated through the generator.

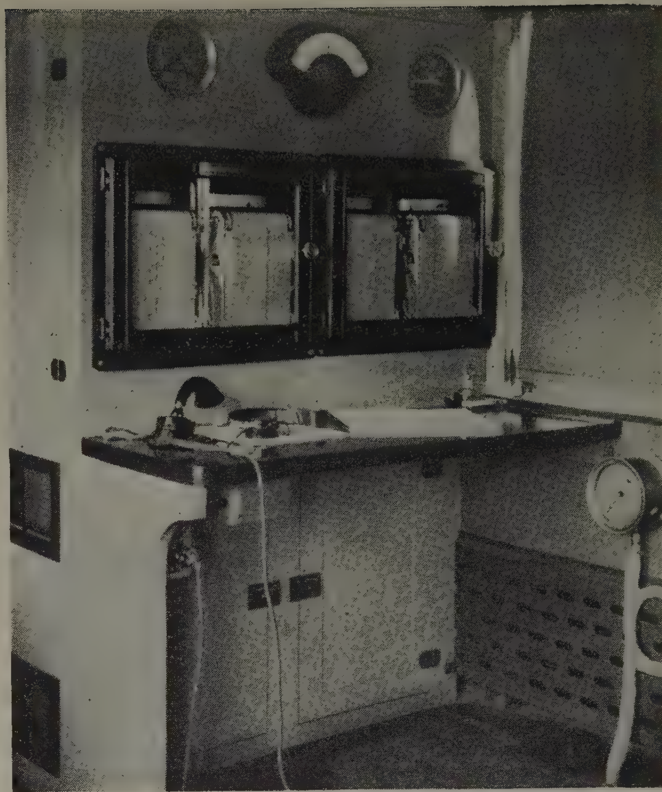

**Figure 1. Cabinet with two twin graphic instruments and telephone**

## SWITCHGEAR AND CONTROL EQUIPMENT

One class of locomotive had many locomotive unit failures occur due to poorly designed contacts on the switch used for the transfer of motor connections from power to braking. These contacts cannot be made trouble-free with any reasonable amount of shop maintenance and have been responsible for many train delays and tonnage reductions.

Another item that has caused much trouble from a maintenance standpoint is the design of interlock contacts. On one make of locomotive trouble from interlock contacts has been negligible, while on a competitive make of locomotive this important item has been the cause of numerous delays and costly maintenance.

A third problem that has caused concern on the part of maintenance forces is the type of equipment used for transition control. On one make of locomotive, control is by use of an axle generator which transmits a wheel-speed signal to three or more relay panels which control motor transfer switches. A special drive and test meter are required for satisfactory checking of this equipment. With all of this, maintenance is often reduced to guesswork because road operation is difficult to duplicate in the shop.

As a contrast, equipment performing similar control functions on another make of locomotive has been reduced to three rather simple relays. Special equipment for testing in this case involves a small motor-generator set and voltmeter. With this equipment, few cases of trouble have been experienced that cannot be corrected in the shop.

From a railroad maintenance point of view, the simplest method of accomplishing a given result is generally the best. This is true even though the final accuracy of the simpler method may not be as good as a more involved and costly method. Much help also could be given maintenance forces by the manufacturers in prompt correction of recognized faulty designs.

Control equipment on some locomotives is installed in such a compact mass that it is almost impossible to reach some devices or terminals to clear faults which develop. These places are not necessarily inaccessible during the construction at the manufacturing plant, but are rendered so when the hood or housing is placed over them. If designing engineers had the responsibility for maintenance, they would give more thought to the accessibility feature.

## TRACTION MOTORS

On one particular make of traction motors it is necessary to grind commutators at 150,000- to 200,000-mile intervals, while two competitive makes do not have a similar condition. These commutators, when checked with a dial indicator, show variations up to 0.012 inch and vary between the three brush tracks. Commutator surfaces show a series of flat spots which may span several bars and very seldom extend across the entire commutator face. The manufacturer attributes this condition to stall burns, but it is difficult to understand why similar conditions are not prevalent on other makes of locomotives operated by the same personnel in identical service, unless it is because of differences in load control methods.

## ON-THE-ROAD TESTING

An all-steel passenger car fitted for on-the-road testing has an instrument or office room, sleeping accommodations for nine people, kitchen, dining room, and a room

for the attendant. The forward end of the car contains a cabinet, with desk attached, in which are mounted two twin graphic instruments (generally operated at a chart speed of 12 inches per hour) containing the following elements (see Figure 1):

Wattmeter for recording main generator output.
Speed recorder operating from generator, belt-driven from car axle.
Voltmeter for recording main generator voltage.
Ammeter for recording traction motor current.

Each instrument is fitted with two chronograph pens, one on each being operated simultaneously by a push button and generally used for marking mileposts on the margin of the charts. Two of the other chronograph pens record service and emergency brake applications.

A telephone headset and chest transmitter is located at the desk in front of the instruments and is used for communication with one or both cabs of the locomotive by the use of portable telephones.

Test leads, calibrated with the instruments, are in two parts and fitted with heavy-duty connectors. The portions attached to the instruments are permanently installed in the car and lead out through the vestibule for convenient connection to the portion of the cables used on the locomotive. All road locomotives are fitted with openings in the nose section for the accommodation of the locomotive portion of the cables which are secured with strain-relief bushings and special lock nuts. See Figures 2 and 3.

With these instruments an undesirable feature in gener-


**Figure 3. Test cables connected between test car and locomotive**

**Figure 2. Calibrated test leads with heavy-duty connectors permanently attached to test car**

ator control was found which caused the generator to operate at subnormal rating for $7^1/_2$-minute periods during the process of making forward transition on traction motors. When this was brought to the attention of the manufacturer's representatives, they said that they had delivered large quantities of similar locomotives to larger roads and had never received similar complaints from them. This trouble was overcome by their engineers, but probably would have been passed unnoticed if a complaint had not been registered.

In another case, trouble appeared with cycling from transition 2 to 3 and back to 1. To correct this trouble the manufacturer's engineering department made a modification which was applied to all units of that class. At the completion of this modification the performance had not been helped, but continued tests with graphic instruments enabled one of their engineers in the field to solve the problem and eliminate the trouble.

On a recent lot of locomotives with 80-mile-per-hour gearing, a severe sagging occurred in the horsepower curve at 50 to 55 miles per hour whereas the design curve showed this break in the curve should not occur until a speed of 69 miles per hour was reached. As was the case with another make of locomotive, many similar units were sold to other roads who made no complaints of this nature. The latest advice on this matter is that, through some miscalculations in the engineering department, traction motor field shunting resistors of improper values were applied.

Invaluable information has been obtained by road testing with graphic instruments in the test car, and shortcomings which never could have been found by load testing devices in the shop have been detected. Both types of testing are now considered essential.

# Progress in Quality Electronic Components Subject of Joint Symposium in Washington

Attended by more than 1,000 electronic engineers and technical authorities, the symposium on "Progress in Quality Electronic Components" was held in the Auditorium of the Department of the Interior, Washington, D. C., May 5–7, 1952. The conference was sponsored by the AIEE, Institute of Radio Engineers, Radio-Television Manufacturers Association, and participated in by agencies of the Department of Defense and the National Bureau of Standards. An up-to-the-minute report was presented at five technical sessions by 40 speakers on the newest components and basic materials.

At the opening session on Monday morning, J. G. Reid, Jr., National Bureau of Standards and chairman of the Symposium Committee which was responsible for the excellent program and the arrangements, welcomed the guests and then presented the chairman of the session, A. V. Astin, Acting Director, National Bureau of Standards, who briefly covered the subject of the session, "Electronics Today."

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### Future AIEE Meetings

**Pacific General Meeting**
Hotel Westward Ho, Phoenix, Ariz.
August 19–22, 1952
(*Final date for submitting papers—closed*)

**AIEE-IRE Conference on Telemetering**
Long Beach, Calif.
August 26–27, 1952

**AIEE Participation in Centennial of Engineering**
Congress Hotel, Chicago, Ill.
September 10–12, 1952
(*Final date for submitting papers—closed*)

**Fall General Meeting**
Jung Hotel, New Orleans, La.
October 13–17, 1952
(*Final date for submitting papers—closed*)

**Middle Eastern District Meeting**
Commodore Perry Hotel, Toledo, Ohio
October 28–30, 1952
(*Final date for submitting papers—July 30*)

**AIEE Conference on Machine Tools**
Ten Eyck Hotel, Albany, N. Y.
October 29–31, 1952

**AIEE Special Technical Conference on Electrically Operated Recording and Controlling Instruments** (*page 666*)
Benjamin Franklin Hotel, Philadelphia, Pa.
November 17–18, 1952
(*Final date for submitting papers—July 17*)

**Joint AIEE-IRE-ACM Conference on Electronic Computers**
Park Sheraton Hotel, New York, N. Y.
December 10–12, 1952

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Glen McDaniel, president of the Radio-Television Manufacturers Association, spoke on "Electronic Production Requirements From Industry's Viewpoint." He commented on the heavy responsibility which rests on the electronics industry to provide the necessities in this field needed by the Department of Defense and then talked about but two of the main problems. The first of these is the lack of project responsibility in electronics procurement and the second is the repeated appearance of obstacles to the electronics industry's effort to spread the work load and broaden the base of electronics procurement.

"Electronics in the Defense Production Program" was the title of a talk by J. A. Milling, Chairman, Electronics Production Board, Defense Production Administration. The basic objective of the Defense Production Administration and the National Production Authority is to conduct a program which has the following points:

1. The production of large numbers of military items.
2. The building of a base from which larger numbers of military items could be produced, if required.
3. Expansion of basic industrial capacity to support both military and civilian requirements.
4. Maintenance of reasonable levels of civilian production during this build-up.

Mr. Milling stated that one of the most urgent problems facing the electronics industry today is to establish a realistic program of standardization for reliable tubes and components. The military demand has steadily increased since the start of the Korean trouble and this increasing demand is expected to continue until early 1953 when it should level off and continue at a constant rate through 1955.

Captain Rawson Bennett, United States Navy, Bureau of Ships, spoke on "Some Factors in Today's Electronics Production." He described the new Electronics Production Resources Agency of the Department of Defense and two new things which it has done: first, with the help of military customers, it has secured a reasonably good estimate of parts requirements; and second, with the help of industry and, in particular, component committees, it has obtained categorization of components by productive process. Based on these breakdowns, the capacity of industry has been estimated.

Reasonable planning data, if made available to the industry, would provide manufacturers with the means for intelligent planning and so would ease production problems, one of which is reliability of components.

"Reliability of Military Electronics" was the subject of a talk by E. A. Speakman, Vice-Chairman, Research and Development Board, Department of Defense. The failure of electronic equipment not only endangers lives of military and civilian personnel, but also jeopardizes the success of military operations. Low reliability of components causes heavy demands on skilled personnel and maintenance people, but it often requires the expenditure of money many times the cost of the original equipment; it also involves problems in production and supply facilities, since it has been estimated that for every tube in a socket, there should be one on the shelf and eight in the supply line.

In our attempt to achieve the ultimate in performance of electronic equipment, it is being made more complex and this has reduced reliability to the degree that it threatens the success of new weapons. For example, in 1937 only 60 tubes were used on a destroyer; this was increased in 1944 to 850 and today the figure is 3,200; in a mobile search radar, more than 500 tubes are used, and the number of tubes used in a flight of bombers runs into the thousands. Manufacturers state that tubes can be produced which are five times as reliable as those in present use, but they cost twice as much; even so, the extra cost is worth while. Complexity of equipment should be reduced as much as possible, and reliability of components must be increased.

C. B. Lindstrand, Electronics Production Resources Agency, Department of Defense, talked on "Electronic Components in Continental Europe." In general, production facilities throughout Europe are operating on an average of 60-per-cent capacity on a 1-shift basis; component quality is good; and considerable development work is taking place. Europeans are not, as yet, under the stress of a large military program which insists on rigid component specifications, and as theirs is a buyer's market where price is a main consideration, mass-produced components are not up to American standards. It can be stated that European manufacturers are beginning to look to American and British specifications as a guide to quality. Prices of components in Europe are about 30 to 50 per cent lower than in the United States, which is partially due to the lower wages of approximately the same percentages.

The final paper of the morning session was presented by G. W. A. Dummer, Telecommunications Research Establishment, London, England, in which he discussed "Electronic Components in Great Britain." The engineering department of the Telecommunications Research Establishment (TRE) conducts all the testing of components for the army, navy, and air force and reliability has increased since the start of this program. Fault reports from the services are compared with the Establishment's own efforts and those of the Atomic Research Department. Research is the main job of the TRE and then manufacturers take care of production problems, thus affording close co-operation between the two.

A central stores has been established for new components, where requirements from all agencies are collected and manufacturers are given a total contract. Upon its com-

**Speakers at the recent Joint Symposium on Progress in Quality Electronic Components were, left to right: J. G. Reid, Jr., Chairman, Joint Symposium Committee; C. B. Lindstrand, lieutenant-colonel, United States Air Force, Electronics Production Resources Agency; A. V. Astin, Director, National Bureau of Standards; J. A. Milling, Chairman, Electronics Production Board, Defense Production Administration; Glen McDaniel, President, Radio-Television Manufacturers Association; E. A. Speakman, Vice-Chairman, Research and Development Board, Department of Defense; Rawson Bennett, captain, United States Navy Bureau of Ships, Department of Navy; W. A. G. Dummer, Telecommunications Research Establishment, London, England**

pletion, the entire output goes to the central stores from which it is distributed.

The TRE is conducting research on mechanization of production and it is believed that printed circuits will lend themselves to a better reliability of components and circuits, as this process will eliminate the human-error factor to a great extent. Mr. Dummer illustrated the manufacturing of some of the printed circuits in England by motion pictures.

BASIC MATERIALS AND MINIATURIZATION

The second session of the symposium covering basic materials was presided over by J. H. Koenig, Rutgers University. The first paper, "Recent Developments in Ceramic Dielectrics," was given by E. J. Smoke, Rutgers University, in which he described the ceramic research project sponsored by the Signal Corps and the properties of some of the materials with which they have been working. Robert Steinitz, American Electro Metal Corporation, presented "Metallic Refractories, New Materials for the Electrical Industry." While there is one limitation to their use, the difficulty of production, the combining of titanium, tantalum, zirconium, molybdenum, and so forth, with borides, carbides, nitrides, and silicides, has resulted in good conductors which are resistant to oxidation at high temperatures. Some of these new refractories make excellent cathodes as they are good electron emitters. The speaker urged his listeners to tell the metallurgists what properties they desire in refractories and chances are good that these properties will be forthcoming.

"Some Fluorochemicals for Electrical Applications" was given by N. M. Bashara, Minnesota Mining and Manufacturing Company. These fluorinated liquids are fireproof and have good electrical properties. The speaker described freon and sulphur hexafluoride and their spark voltage and corona properties. The general properties of the liquids showed them to be good for heat transfer around 100 to 400 degrees centigrade. R. L. Griffeth and E. R. Younglove, Mica Insulator Company, presented "Manufacture of Mica Paper for Insulation" (see *EE, May, '52, pp 563–5*).

The last paper of the session, "Progress in the Use of Teflon," was given by M. A. Rudner, United States Gasket Company. Teflon, which is produced from freon, is moldable, can be machined and extruded. It has a high compression ratio and can be surfaced with a metal, thus making it possible for it to be plated and welded. In subminiature vacuum-tube sockets, the solder connecting the elements to the pins is built in and when heat is applied to the prongs, they become soldered. It can be used as a base for printed circuits with feed-through terminals, as it is one of the industry's best dielectric materials.

After a short recess, the second technical session covering advances in miniaturization started with Cledo Brunetti, Stanford Research Institute, as chairman. The first paper, "Compact Assembly Methods," was given by S. F. Danko, Signal Corps Engineering Laboratories, Fort Monmouth, N. J., where the autoassembly technique has been introduced. The process steps in the fabrication of printed circuits were described where the components are mounted on metal-phenolic laminate as they are tested. Long-pin sockets and connectors are used for decking as also are T-pin connectors, which are pins at right angles to the blocks. Assembling by solder-dipping is very fast and a selective soldering technique has been developed whereby only certain connections are soldered when the assembly is dipped.

W. H. Hannahs and J. Eng, Sylvania Electric Products, Inc., presented "Reproducibility of Printed Components." It was brought out by Mr. Hannahs that printed circuits mean lower rates, and the fewer of these circuits which are rejected in their manufacture, the lower the cost will be. He described the steps in the processing of resistors by the silk-screen method of printing, which takes approximately 4 hours. He also gave statistical data for sampling in the different steps in the silk screen process.

The final paper for the session was given by P. S. Darnell, Bell Telephone Laboratories, "Miniaturized Components for Transistor Application." He described how the transistors were especially well adapted for miniaturization and then told how resistors, coils, broad-band filters, capacitors, and so forth, have been reduced in size so that they can be packaged with transistors to make very small units.

RESISTORS, CAPACITORS, AND INDUCTORS

The first session on Tuesday morning was devoted to the subject of resistors and presided over by Professor Ernst Weber, Polytechnic Institute of Brooklyn. The first paper, "Adhesive Tape Resistors," was given by B. L. Davis, National Bureau of Standards, who reviewed the subject of printed circuits after which he discussed the use of silicone resins as tape resistors. These are pressed in position on a ceramic printed circuit and baked at 300 degrees centigrade for 4 hours. In a 500-hour life test, these resistors are off between −2 or −3 per cent.

"Metallic Film Resistors" was the subject of a paper by C. T. Graham, Polytechnic Research and Development Company. These resistors are formed by a thin ceramic lustre onto glass tubing and then on this a chromium layer is applied. Values from 1 to 10,000 ohms are obtainable and by means of a spiralling technique, values up to 500,000 ohms are made in 0.5-, 1-, and 2-watt units. In an accelerated aging test, the maximum change was 0.16 per cent. Special potentiometers of metallic films are being developed.

C. K. Hooper, Westinghouse Electric Corporation, read a paper on "Stability of Standard Composition Resistors" in which he reviewed the properties of standard composition resistors and the fact that temperature constancy is perhaps the most important factor. He described the series of tests and brought out that after 1,000 hours, most resistors showed a relatively small change in

value with those of 1-watt rating showing less change than those of 2 watts. The products of three manufacturers were tested and most of the resistors satisfactorily passed the Joint Army-Navy (JAN) tests.

George Kende, International Resistance Company, presented "Borocarbon Resistors." The deposited-carbon resistors were first produced in Germany in 1930 and little was done with them until lately. The temperature coefficient was reduced by using a boron-on-carbon process in which the coating is spirally cut until the desired value of resistance is reached. The temperature coefficient of the boron-carbon type is better than the deposited resistor up to values of 10,000 ohms.

The final paper of the session was presented by J. K. Davis, Corning Glass Works, on "E-C Glass Resistors." These units consist of a special coating, of the order of a wavelength of light in thickness, bonded on a tube of heat-resistant glass. The resistive coating is spirally cut to a 0.5-per-cent tolerance. The temperature coefficient is less than 200 parts per million per degree centigrade, and in a 700-hour life test, the resistance was down about 1.5 per cent. These resistors are said to be unaffected by humidity and to have a good high-frequency characteristic up to 400 megacycles. Physically they are smaller than wire-wound power resistors and have a good power rating.

After a brief recess, the session on capacitors and inductors was opened with J. K. Sprague, Sprague Electric Company, in the chair. The first paper, "Capacitors for High-Temperature Operation," was given by J. W. Schell, Erie Resistor Corporation. He described the tests being conducted under a Signal Corps contract for a covering for ceramic capacitors which will hold up between temperatures from −55 to +200 degrees centigrade. One under development at present is a silicone-fibre glass coating which shows promise.

Gail Smith, Corning Glass Works, read a paper, "Expected Performance of Glass Capacitors," in which he compared glass and mica insulation. Capacitors of glass dielectric are practically independent of frequency and the drift is also almost zero. Such capacitors can be made very small physically and have a better Q than mica with a higher voltage rating.

"Tantalytic Capacitors" was read by L. W. Foster, General Electric Company. These tantalum capacitors are intended to replace aluminum-paper units as they can be made small physically, have low weight, and have a good shelf life at 85 degrees centigrade.

G. E. Walter, General Electric Company, reported on "Progress in Size and Performance of Transformers" in which he brought out that lighter transformers were needed which should function up to 150 degrees centigrade for a minimum of 1,000 hours. The designer should have all the operating data as well as the expected life in order that the tests for ambient temperature, vibration, humidity, and so forth, can be passed satisfactorily. He made a plea for better specifications and definitions.

The final paper of the session was presented by W. W. Stifler, Jr., Ferroxcube Corporation of America, "Ferrite Inductor Cores." These ceramic cores can be used in wide-tolerance transformers, as the variation of these cores must be taken into consideration because they can not be machined readily. To date, the manganese-zinc ferrites are obtainable, but the nickel-zinc ferrites are getting scarce.

MISCELLANEOUS COMPONENTS

Fuses, relays, vibrators, instruments, and wire were considered at the session on Tuesday afternoon, over which J. H. Miller, Weston Electrical Instrument Corporation, presided. The first paper, "Selection of Fuse Protection for Electronic Circuits," was presented by E. V. Sundt, Littlefuse, Inc. An outline of the standard fuse types for the electronic industry was given, with examples shown of the bead, filament, and element types. It was brought out that the time-current factor in fuses is related to the time-damage of the components which they protect. Fast fuses are used for meters, flashover protection, and so forth, and the slow fuses in vibrator, solenoid, and motor circuits. The trend is toward smaller fuses and holders.

J. R. Fry, Bell Telephone Laboratories, Inc., discussed "Design Factors Influencing the Reliability of Relays." These factors are contact pile-up stability; coil construction; contact reliability; magnetic and structural stability. It was stressed that in aircraft and missile relays, dynamic shock is one of the most important factors which must be considered above others which seemingly are of more importance.

"Vibrators for the Armed Services" were considered by K. M. Schafer, P. R. Mallory and Company, Inc. Mr. Schafer traced the history of the development of vibrators and their expanding use from that of a half-wave rectifier to the present units which have a full-wave output. F. X. Lamb, Weston Electrical Instrument Corporation, next discussed "Indicating Instruments for Use Under Severe Conditions." He described a new type of movement mounting and the construction of the meters, which also have a new type of zero corrector.

"Influence of Wire and Cable on Improved Components" was presented by F M. Oberlander, Radio Corporation of America. All wiring should insure circuit constancy and, as copper oxidizes above 100 degrees centigrade, a silver coating on the copper wire retards this action. Copper-covered steel wire is finding wide use, but copper wire conducts heat away from components more efficiently. Plastic insulation is replacing varnished cambric and rubber, with low-loss polyethylene covering being used successfully as well as nylon insulation, but the latter is too stiff for hook-up purposes. It was urged that equipment designers should

# McEachron Is Outstanding New England Engineer

**Dr. Karl B. McEachron of the General Electric Company, Pittsfield, Mass., who was selected as the outstanding engineer resident in New England, is shown (center) being presented with the annual award for 1952 of the Engineering Societies of New England (ESNE). The award, selected by committee votes from nominations submitted by various engineering societies affiliated with ESNE, cites Dr. McEachron as "an electrical engineer who has won new laurels for his country as a pioneer in the understanding and control of natural lightning; a prodigious contributor to the art; and a devoted servant of his profession." Shown with Dr. McEachron at the award presentation in Boston are Philip Rugg (left), ESNE president, and Kerr Atkinson, chairman of the award committee**

consult wiring engineers before their designs are too far advanced.

The final paper of the session was presented by C. E. Dodge, Jr., Warren Wire Company, entitled "Teflon Wire." This polymer can be coated on a copper wire and fused on it at 800 degrees centigrade, its dielectric strength depending on the thickness of the coating. It is resistant to temperatures from 220 to 300 degrees centigrade; at 215 degrees no cracks developed after 1,000-hour life tests. At 400 degrees centigrade, teflon will dissolve off the wire and that is the method used for stripping the ends. Copper and silver wire have been coated successfully and good results have been obtained with teflon coatings on steel, stainless steel, and aluminum wire. It also has good abrasion characteristics.

### DESIGN AND PRODUCTION

After a recess, three papers devoted to design and production problems were presented with M. R. Briggs, Westinghouse Electric Corporation, presiding. The first paper, "Production Problems Concerning Polyester Plastic Embedments," was given by D. G. Heitert, Emerson Electric Manufacturing Company. Although plastic embedments presented many problems in the production of packaged units, especially those for use in aircraft electronic equipment, they have been solved profitably and practically. A new way to mix the ingredients quickly is with a paint mixer with a medium rise in temperature and thoroughly mixed with an homogenizer. It is important that the ovens' temperature be changed at definite periods and in definite increments and it is here that automatic control equipment is necessary.

Walter Robinson, Ohio State University Research Foundation, in his paper, "Heat Transfer From Electronic Components," explained the formulas for calculating the removal of the heat generated in a packaged unit from the components. The session was closed with the presentation of "Packaging Principles Employing Plastics and Printed Wiring to Improve Reliability" by W. J. Clarke and N. J. Eich, Bell Telephone Laboratories, Inc. After listing the factors which influenced reliability, as high-quality components, rugged assembly, adequate sealing to combat humidity, wide ambient operating temperature, and so forth, he showed examples of printed wiring and component assemblies. He differentiated between casting and molding. By the former is meant the making of a plastic box for enclosing the components by pouring the plastic ingredients into a mold and then lifting the solidified unit out; and by molding is meant the pouring of the plastic into a mold which becomes an integral part of the package. Thermosetting resins seem to be the best for packaging, but fillers must be used to provide the proper properties. Nothing which has an inhibiting effect on the plastics, as rubber insulation, should be employed.

### TRANSISTORS

On Tuesday evening J. A. Morton, Bell Telephone Laboratories, Inc., opened the meeting of which he was chairman, with a short history of the development of the transistor to its present state and then introduced the first speaker, W. R. Sittner, Bell Telephone Laboratories. Although a great deal has been accomplished in the transistor's development, there is still much to be done in order to obtain the desired reliability. Their present life test indicates that they will have an expectancy in the neighborhood of 75,000 hours or better; in shock tests they have withstood 20,000 g's and in vibration tests up to 1,000 g's with no modulation. The speaker demonstrated some of the electrical characteristics.

P. S. Darnell, Bell Telephone Laboratories, Inc., told about some of the miniaturized components which are used in transistor packages. He showed some of these to the audience by means of a magnifying shadow projector.

"Transistor Power Amplifiers" were demonstrated and explained by R. F. Shea, General Electric Company. After discussing the transistor circuitry, the speaker demonstrated a 2-transistor amplifier driving a megaphone, the small batteries being packaged with the amplifier components. Two amplifier units connected to a record player were then demonstrated. The first, containing four transistors, was a class *A* amplifier and operated on approximately 1/16 of the input power necessary to drive comparable tubes. Its 0.2-watt output was used to drive a 2-transistor push-pull amplifier, which in turn amplified the recorded music at about one watt, one of the highest outputs achieved with transistors.

The final speaker of the evening was Lieutenant Colonel W. F. Starr, United States Army, who provided data on the availability of transistors. Six manufacturers plan to have transistors on the market before the end of 1952 and two others have not specified any date.

### RELIABILITY

J. A. Chambers, Motorola, Inc., was the chairman of the session which was devoted to aspects of reliability and at which seven papers were presented. The first speaker was J. H. Muncy, National Bureau of Standards, whose subject was "Electronic Failure Prediction." He defined failure prediction as the measurement of functioning of equipment which will show an incipient failure. A communication set was used as an example in which the individual stages could be measured and checked by a system of quick switching from one to the next. Measurements are made of transconductance, grid current and voltage, and plate current and voltage of each stage. The parts which do not measure up to standard are left in the set to ascertain how long they will last. By this means several tens of hours warning are obtained.

"Component Failure Problem in Navy Electronic Equipment" was the title of a paper by M. M. Tall, Vitro Corporation of America. Naval electronic equipment must operate under all conditions in crowded spaces and on ships 90 per cent of the equipment must be ready to function 24 hours per day, even if it is operating at low values. An analysis has been made of the failures of components and resistors were found to be the worst offender, with capacitors next, followed by connections, switches, transformer coils and chokes, relays, meters, and so forth. In order to reduce the stock of spare parts of different values, it was recommended that more parts of the same values should be employed in equipment.

"How Can the Reliability of Electronic Systems Be Improved?" The answer to this question was provided by W. Wagenseil, Hughes Aircraft Company, by a description of the way the problem was handled in his company. Failure reports of all sorts were studied and no outstanding cause could be found; however, it was established that chance failures predominated. The more complex the equipment was, the greater the number of failures; for example, radar sets had more failures than radio equipment. In government reports, 60 to 70 per cent of the troubles were traced to vacuum tubes and in the company reports, tubes accounted for about 30 per cent of the failures with wiring connections to plugs about 6 per cent. It was found that the same parts failed in different applications and the same types of failures occurred throughout the equipment; parts not used frequently tend to fail oftener than those which are in constant use. It was recommended that parts applications engineering departments be set up so that equipment designers could obtain data on components from parts engineers to guide them in their choice. This would eliminate to a great extent the failure of components which were not designed to function under certain conditions and yet would be satisfactory when used in other circumstances.

D. E. Brown and V. Harris, Vitro Corporation of America, presented "Component Parts Specifications," which was read by the latter. A great many inconsistencies exist in governmental specifications for electronic components, especially in that the qualities of components are insufficiently covered. Equipments in which components are incorporated which have passed their particular tests, have failed under different tests not specified for the components. It was recommended that requirements should be brought up to date and that mechanical as well as electrical tests should be conducted under all conditions.

"A Component Manufacturer Looks at Reliability" was the topic discussed by Leon Podolsky, Sprague Electric Company. Some of the factors responsible for the poor showing of components in the field are: designers who are ignorant of components capabilities; too often price considered ahead of quality; use of components in places for which they were not designed. There should be a much greater liaison between the manufacturers of components and designers who put them into equipment. Component manufacturers should co-operate with engineering schools so that the young graduates will be familiar with their products.

M. A. Jones, Aeronautical Radio, Inc., spoke on the education of the public in electronics. Because electricity in general, and electronics in particular, is a mystery to the public at large, the misuse of electric apparatus is so widespread. It was suggested that an educational campaign be directed at the public on the electronic arts using the facilities of television, radiobroadcasting, magazines, and so forth.

### TUBES

C. R. Banks, Aeronautical Radio, Inc., was the chairman of the final session, which was devoted to the subject of electron tubes. The first paper, "Sealed-in-Glass Germanium Diodes," was given by J. W. Dawson, Sylvania Electric Products, Inc. Ger-

manium diodes must be sealed against humidity effects so that they will not drift. A comparison was drawn between the use of porcelain and glass for sealing these units and a description was given of the improvements in their characteristics in the last 3 years.

P. T. Weeks, Raytheon Manufacturing Company, presented "Reliable Ruggedized Subminiature Tubes" in which he traced the history of the development of miniaturization since the end of World War II and how the subminiature tubes had evolved from the *6AK5* and *6AS6*. R. L. Kelly, Radio Corporation of America, in his paper on "Methods for Achieving Maximum Reliability in Vacuum Tube Applications," brought out that while the cathode supplies electrons, it also has contact potential. In order to eliminate this trouble, the heater voltage should be held constant. Contact potential also changes with the life of the tube, the greatest change occurring in the first 100 hours—another reason for the manufacturer to give tubes a life test. As barium is always being evaporated from the cathode and condenses on the grid, that element also emits electrons as it receives some heat energy from the heater. There is also some secondary emission from the grid due to the bombardment from the cathode. All these facts should be familiar to equipment designers so that proper precautions can be taken.

The final paper of the session, "Failure of Vacuum Tubes From Interface Formation," was by W. H. Kliever, Minneapolis-Honeywell Regulator Company, and read by Mr. Rexer. In a series of tests in house-heating regulators wherein the filaments of tubes were left on all year, but plate voltage was applied only partially, it was found that the resistance of the cathode was built up and formed an interface, which shows up on a tube checker as low emission. A great number of tubes were given 200-hour tests and the tubes which passed the interface test varied greatly according to type and manufacturer.

The symposium was brought to a close by J. G. Reid, Jr., who thanked the attending engineers for their co-operation during the sessions and announced that the papers would be published sometime during the summer in book form at a cost of $5 per copy. Orders may be sent to R. S. Gardner, AIEE Headquarters, 29 West 39th Street, New York 18, N. Y.

# Electronic Converter Applications and Tubes Subject of Pittsburgh Conference

Approximately 250 engineers from as far away as Louisiana, California, Washington, and Canada, gathered in Pittsburgh, Pa., for the Conference on Electronic Converter Applications and Tubes, May 19–20, 1952.

Twenty-two papers were presented by representatives of both the manufacturers and users of power converters. These papers, which covered all phases of the power-rectifier field, included general theory and basic principles of the various types, standardization, application, operation, and maintenance.

The conference was sponsored by the AIEE Committee on Electronic Power Converters and the Subcommittee on Electron Tubes of the Committee on Electronics jointly with the AIEE Pittsburgh Section.

It was the third of a series of conferences devoted to electron tubes and their applications. The first of these conferences was held at Philadelphia, Pa., in December 1948, and covered "Electron Tubes for Instrumentation and Industrial Use." The second conference was held at Buffalo, N. Y., in April 1949, on "Industrial Applications of Electron Tubes." Both of these meetings considered mainly smaller tubes of the types used in signal and control circuits.

This third conference was devoted to larger power tubes and equivalent devices, such as metallic rectifiers and mechanical rectifiers. These power conversion devices find wide use in supplying direct current for the reduction of aluminum, electrochemical plants, street railways and railroads, coal mining, steel mills, and many other applications where direct current is required.

C. C. Herskind, General Electric Company, opened the conference with a discussion of the purpose of the conference and a brief review of the history of the various devices used to produce direct current since the advent of the d-c generator in 1882. He noted that the first true rectifier was the glass-bulb rectifier introduced about 1904. The first metallic rectifier was made of copper sulphide and was introduced about 1912. The modern rectifiers, such as the ignitron, excitron, mechanical rectifiers, and selenium rectifiers, have all been introduced during the past 15 years.

On Monday afternoon, two inspection trips were conducted to neighboring plants of the United States Steel Company and the Westinghouse Electric Corporation. At the former, the visiting group was shown through an open-hearth plant, a slabbing mill, and a plate mill at the Homestead Works. At the Edgar Thomson Works, a 20,000-kw electronic frequency changer was shown in operation. This frequency changer connects a 60-cycle power system to a 25-cycle power system and permits the exchange of power between the two in either direction.

At the East Pittsburgh Works of the Westinghouse Electric Corporation, the visitors were taken through the ignitron rectifier manufacturing and testing facilities and the switchgear manufacturing section. Pumped and sealed ignitron rectifier units of a wide variety of current and voltage ratings were shown in varying stages of manufacture. Sealed ignitron tubes capable of operating at 20 kv peak inverse voltage and 150 amperes average current also were shown in operation.

Considerable interest was shown in a panel discussion held on Monday evening in which the basic theory and field of application of each type of rectifier unit was described, after which the meeting was opened to general discussion from the floor. The session was presided over by Dr. C. H. Willis, Princeton University. Papers were presented on the following types of rectifier elements: "Ignitrons," A. Schmidt, Jr., General Electric Company; "Excitrons," C. Winograd, Allis-Chalmers Manufacturing Company; "Hot Cathode Tubes," H. H. Steiner, General Electric Company; "Metallic Rectifiers," I. R. Smith, Westinghouse Electric Corporation; "Mechanical Rectifiers," O. Jensen, I-T-E Circuit Breaker Company (read by L. Keltz); and "Glass Tubes and European Manufacture," J. T. Thwaites, Canadian Westinghouse Company Ltd. (read by L. A. Casanova, Westinghouse Electric Corporation).

During the course of the discussion, E. A. Harty, General Electric Company, briefly discussed the new germanium p-n junction-type rectifier which is just making its appearance commercially. This new rectifying element promises to make an important contribution to power conversion, especially in the low-voltage field.

Tuesday's session was devoted to applica-

**Among those participating in the panel discussion on the theory and application of the various types of rectifier units were, left to right: A. Schmidt, Jr.; I. R. Smith; L. A. Casanova; Dr. C. H. Willis (who presided); H. C. Steiner; L. Keltz; H. Winograd**

tion, operation, and maintenance practices. A number of rectifier users recounted their personal experiences on operating and maintaining the different types of rectifiers in the various industries. The difficulties which they had encountered and the manner in which they were overcome were thoroughly covered by these users and made a valuable contribution to the conference. This was an excellent opportunity to learn directly from "the man who owns one."

Guest speaker at the Tuesday luncheon meeting was D. I. Bohn, Chief Electrical Engineer of the Aluminum Company of America. He gave an interesting talk on "What Can Be Done to the Design and Construction of Household Electric Appliances so That Many of Us Need Not Spend More Effort and Time Keeping Them Working Than Our Wives Save by Having Them." The title hardly requires further explanation.

A recent AIEE survey on rectifier operation was presented at this meeting. This extensive survey covers most of the active rectifier users and units in operation. It gives much detailed information regarding the application and performance of these units in all the various fields of application, such as electrochemical, mining, railway, steel, general industry, and so forth. Copies of the survey are available from AIEE Headquarters, 33 West 39th Street, New York, N. Y., for $1.50 (75 cents to AIEE members).

Also presented at this conference was a preliminary report on a survey now being conducted on "Rectifier Cooling and Corrosion Problems." This deals exclusively with the cooling system of mercury-arc rectifiers. Its intent is to draw upon the many years experience of the manufacturers and users of these rectifiers with all types of cooling systems and to make this experience available to all.

The entire proceedings of this conference will be published in a bound volume in the near future. Copies may be obtained from AIEE Headquarters. The price is $3.50.

The sponsors of this conference wish to express their sincere thanks to all the companies and persons who participated in arranging this conference and who presented papers.

# Textile and Electrical Industries Participate in Atlanta Conference

The Southern Conference on Electrical Application for the Textile Industry held its session on May 1–2, 1952, at the A. French Textile School, Atlanta, Ga., with widespread participation by both the textile and the electrical industries. The conference was under the joint sponsorship of the AIEE Georgia Section, the AIEE Textile Industry Subcommittee, the A. French Textile School, and the School of Electrical Engineering, through the Engineering Extension Division of the Georgia Institute of Technology, Atlanta. All of this was made possible through the co-operation of C. H. Taylor, Co-ordinator of Short Courses and Conferences of the Georgia Institute of Technology and his committees, who had prepared and distributed all necessary notices, bulletins, and so forth, to the units of the textile industry in the South with full and detailed coverage, and also the co-operation of J. T. Meador, member of the AIEE Textile Industry Subcommittee, who submitted this report.

The 2-day meeting consisted of a program of three general themes:

1. Textile mill vibration and control.
2. The electrical industry's application of equipment to the textile industry.
3. The textile industry's adaptation of the electrical industry's products.

I. S. Bull, J. P. Stevens and Company, Duncan Mills, Greenville, S. C., presiding over the Thursday morning session, introduced Dr. B. R. Van Leer, President, Georgia Institute of Technology, who, in extending to the members of the group a welcome to the Georgia Institute of Technology, gave an interesting résumé of the efforts and accomplishments of the school in the various phases of their technical courses of study and development.

The first of the three papers of the Thursday morning session was presented by F. J. Crandall, Liberty Mutual Insurance Company, Boston, Mass., whose paper was voted one of the best 25 papers related to the textile industry by the Institute of Textile Technology within the past year.

Mr. Crandall pointed out that the trend of competition in the textile industry necessitated higher speed machinery for the increased production necessary. This has direct reference to looms as the production unit which continually imposed greater forces upon the textile mill building structures in three planes of action, that is, vertically; horizontally through the length of the mill; and most extremely across the width of the mill due to the dynamic unbalance of the looms in operation. When they get in momentary step with each other forces are set up which produce unsafe conditions in the structure. These, in turn, would produce unsafe locations for the textile workers, which is the prime concern of the Liberty Mutual Insurance Company. He illustrated an accelerograph which was designed to measure the accelerations and frequencies of the forces imposed by a mill building wall due to various machinery operations. This accelerograph measured and timed all surges or forces upon a 35-millimeter motion picture film operating at a constant speed, thus allowing the operator to have a permanent record of vibration in any structure under study. Mr. Crandall went through the method of translating these data by means of calculations to the necessary solutions of the problems for correction by any one of three methods of reducing the vibration as follows:

1. Stiffening the structure.
2. Reducing the stiffness of the structure.
3. Balancing the loom.

The second paper presented was by Fred Snyder, Westinghouse Electric Corporation, Boston, Mass., on the subject of "Loom Desynchronizing." (See *EE, June '52, p 569.*)

The third paper, "Vibration Control on High-Speed Twister Spindles," was presented by Hans Wormser, Universal Winding Company, Providence, R. I. (See *EE, June '52, p 559.*)

### MOTOR APPLICATIONS

The afternoon session was led by H. S. Colbath, Bibb Manufacturing Company, Macon, Ga. Maurie Weitekamp, Louis Allis Company, Atlanta, Ga., presented the first paper, written by him with J. J. Kirkish entitled "Matching Motors and Machines in the Textile Industry."

Mr. Weitekamp pointed out that the distribution of individual motor drives has now become a standard for reduced maintenance costs, safety, appearance, and uniform quality of the product.

In applying motors to textile machinery two situations must be considered: 1. the conversion of existing installations from line shafting to single motor drives: and 2. the design of new textile machinery. The former naturally imposes restrictions which are not a factor of the latter, he told the group.

In powering textile equipment the motor manufacturer is faced with three basic considerations:

1. Mechanical construction.
2. Electrical characteristics.
3. Temperature ratings.

These are supplemental to considerations of motor control, all of which influence the final design to a marked degree.

He described three types of enclosures in regard to mechanical construction that are available for different purposes. Motors of small output, 3 horsepower and smaller, can be built totally enclosed, nonventilated, without penalty of frame size since temperature need not be the determining factor. This is the ideal enclosure for lint-laden atmospheres on both cotton spinning and woolen machinery.

Motors of larger output can be built in the self-cleaning or lintfree textile construction and are ideal for cotton spinning mills where there are fibrous dust and lint present. Open motors can be used successfully where there is less fire risk and less danger of motors becoming clogged.

Other factors influencing the final mechanical design include such items as space limitations, special mountings, as well as special bearing design, which, for example, would be necessitated by the continuous vibration and impact action of a reciprocating loom load.

The second paper of the afternoon session was presented by Dan McConnell, Cone Mills Corporation, Greensboro, N. C.: "Maintenance of Electric Equipment in Textile Mills." He explained his company's policies of having their maintenance men carry wigginton testers and never going in on a circuit with their hands or a tool without testing first. They also have several of the smaller tong-test ammeters that have been quite satisfactory for hip-pocket carrying.

They have a project under way of numbering columns in the mills so a geographical

location in any part of the plants can be determined from this column marking. This is just getting started on a test basis.

Since their power system remodeling is now almost complete they will start shortly on a project of numbering their feeders and control equipment. The scheme they propose to use was borrowed from the Dewey Decimal System used in cataloguing library books and may be useful to someone. Each feeder leaving a unit substation will be numbered *1–2–3–4* in arabic numerals. The first disconnect switch or section circuit breaker coming off this feeder will be *A*, the second *B*, and so on. The first control device behind the section circuit breaker will be numbered as *1–2–3*. The number on a magnetic switch on a spinning frame, for instance, might read *3C4*, meaning that it was magnetic switch *4* fed by section circuit breaker *C* from substation feeder number *3*. This helps a maintenance man as he can pull disconnect switch *C* and know how much he has cut off and that he is working behind an open switch. In working with some fairly complicated schematic wiring diagrams recently, they found it useful to mark them up in a manner that essentially gives co-ordinates for each device shown on the schematic.

The third paper was presented by Swaffield Cowan, Factory Insurance Association, Charlotte, N. C. He acted as moderator in the "Discussion on Desired Characteristics of Industrial Enclosures for Textile Mills," after which a ballot was taken with the audience participating and voting for the most preferable type of enclosure to meet the conditions imposed by the textile industry. The results of this ballot will be presented to the National Electrical Manufacturers Association–AIEE Joint Committee for the purpose of developing a suitable enclosure for such purposes.

### VOLTAGE CHARACTERISTICS

The Friday morning session also was presided over by Swaffield Cowan. J. E. Hogan, Okonite Company, Passaic, N. J., presented a paper, "Fundamental Insulation Requirements for Exterior and Interior Power Distribution Systems," in which he pointed out the various voltage characteristics of operating circuits and power-distribution circuits in textile mills and other plants as being in the 0–600-volt class, which included the bulk of power, control, and lighting circuits in industry with 2,300/4,160-volt circuits being widely used as generators and distribution circuits or for large horsepower motors. The 6,600/6,900-volt circuits quite frequently were used for generator and distribution circuits where it was necessary for greater capacities with a trend toward even higher voltage circuits on the order of 15,000 volts.

For each voltage classification, he pointed out the definite advantages of various types of insulations over other types which indicated the advantage of rubber-insulated cables, which were shielded, and of neoprene-sheathed cables which, though slightly more expensive in cost than paper or varnished-cambric cables, provide the reliability of these types for primary circuit distribution and eliminate the need for specialized equipment, such as potheads and lead-wiped splices, and for trained personnel for installation and maintenance.

Mr. Hogan gave some informative tips concerning the use of aluminum conductors in sizes Number 1/0 American Wire Gauge and smaller. The proof of the effectiveness of his paper was demonstrated by the active audience participation in the discussion of the facts which he presented.

The second paper of the morning was "High-Voltage Distribution and Unit Substations and Their Use in Textile Plants" by B. C. Swain of Bibberstein, Bowles and Meacham, Charlotte. Mr. Swain stated that he could have called his paper "High-Voltage Distribution Returns to Textile Plants," inasmuch as several in the audience could remember when 2,300-volt electric power was prevalent voltage in use in textile plants, primarily because of the necessity of large motors of 50, 75, 100 horsepower, or even larger motors spotted to take existing line shaft drive groups, with 2,300 volts being the power supplied by the local power companies by means of straight feed-in service from a common distribution circuit without the power company having to furnish a substation for lower voltage. He suggested that the reason 2,300 volts was discarded in favor of lower voltage was because of the demand for smaller motors required for individual drives. Therefore, 550 volts was chosen as the distribution voltage for textile plants although it was not a standard voltage in any other section of the country. Some authorities say 550 volts is used because some 2,300-volt motors could be reconnected for 550 volts; also, some say that it is on account of utilizing the maximum capacity in the 600-volt insulation class. Mr. Swain pointed out that large textile plants with widespread arrangement have used 2,300 volts, 4,160 volts, and some even have gone as high as 13,800 volts for plant distribution with the resultant performance of less voltage drop and, consequently, less power loss.

The third paper of the morning's session was presented by V. F. Sepavich, Crompton and Knowles Loom Works Company Worcester, Mass., and entitled "The Application of Electric Equipment to Looms and Other Textile Machines." He discussed the evolution of the loom from strictly a mechanical machine to one with mechanical refinements made possible by means of electric controls and drives. This was highlighted by means of slides showing the development of motor-drive application since 1903, which had a flywheel, and he said that they are still talking about flywheels. He brought out the improvements in loom-motor enclosures and bearings and how electric power has increased production by such scope that mechanical drives could not touch. With electric warp stop-devices permitting higher speeds, it was found that drop-wire induced voltages of 300 for duration of 1/5,000 second, dropped and bounced to produce 3 or 4 or 5 picks before stopping the loom, with transformer tripping-out due to overload, caused no voltage trouble. Warp stop-motion correction developed a relay to step down on 1/5,000-second contact.

Mr. Sepavich very effectively used a large number of slides showing various loom developments which he had made in the employment of electric control and drives. He pointed out the effectiveness of external wiring from the starter switch to the motor, as well as from the stop-motion transformer to the warp stop system of the loom. His paper was also widely discussed during the audience participation period and his ideas were roundly applauded.

# H. L. Caswell of Columbia University Gives 24th Steinmetz Memorial Lecture

On Wednesday, May 21, 1952, the Steinmetz Memorial Foundation and the AIEE Schenectady Section presented the 24th Steinmetz Memorial Lecture at the Memorial Chapel of Union College, Schenectady, N. Y. Over 400 people were present to hear Dr. Hollis L. Caswell speak on "The Great Reappraisal of Public Education."

In his introductory remarks D. E. Garr reviewed some of Dr. Steinmetz's life. Mr. Garr, past chairman of the Schenectady Section, pointed out that in addition to his scientific contributions in the fields of lightning, illumination, and a-c machinery laws, Dr. Steinmetz was also interested in the field of education. "He aided in the development of the Electrical Engineering School at Union College, and later was appointed chairman of the Board of Education of Schenectady." Mr. Garr quoted Dr. Steinmetz's reply to a question about his views on education: "I am very strongly of the opinion . . . that a broad education, a good general knowledge of English, literature, languages, is of far more importance and value, for the future success of the engineering student, than instruction in the numerous details of this special profession. I am of the opinion that instruction in the strictly technical courses could be greatly curtailed without any harm, by dropping all those subjects which are not fundamental principles or of use as illustrating fundamental principles, and which the student therefore could learn just as easily and often better after graduation in his engineering practice . . . ."

Mr. Garr went on to state that, "In consideration of Dr. Steinmetz's broad human interest in varied activities and his technical achievements, the Steinmetz Memorial Foundation was established in 1925. His many friends and admirers placed a fund in permanent trust under the administration of the Schenectady Section of the AIEE. The Foundation provides for annual public lectures by eminent men in honor of Dr. Steinmetz. Previous lectures have covered a wide variety of subjects in the fields of science, engineering, education, and industrial technology."

Dr. Caswell is Dean of the Teachers College, Columbia University, and has had a lifetime of experience as a teacher and administrator in the public schools of the United States. He is noted as the author of a variety of articles on the programming and curriculum of the elementary and

secondary schools. He has conducted surveys in many of our large city school systems and has served as consultant for many State Departments of Education. Dr. Caswell has held office in the National Education Association, the Society for Curriculum Study, and the Educational Research Association. In World War II, he acted as chief of the Program Section of the Pre-Induction Training Program for the War Department. He also served as consultant to other Government agencies and for the Army of Occupation in Germany, making a study of the program of educational reform in Bavaria. According to Dr. Caswell: "American schools are receiving a great deal of critical appraisal at the present time, possibly more than in any period since the battle for general tax support during the first half of the 19th century."

"Some of the points raised are superficial and reflect a lack of acquaintance with modern educational practices. Others, however, involve fundamental issues concerning the future course of development of our public schools."

In his discussion, Dr. Caswell attempted to describe and evaluate some of the fundamental features of our public school system that are being subjected to reappraisal by the current wave of criticism.

### STANDARDS OF ACHIEVEMENT

Dr. Caswell stated that: "One of the most common lines of attack relates to standards of achievement. It is asserted or implied that schools do not enforce desirable standards. As evidence, cases are cited of pupils in high school who read at elementary grade levels, or whose skill in arithmetic is comparably low, or whose knowledge of American history or of similar subjects is highly deficient."

Dr. Caswell believes that this line of criticism strikes at one of the most distinctive features of the educational system, our concept of equality of educational opportunity.

Dr. Caswell went on to state that it became evident early in this century that even though pupils stayed in school for several years, a very large number were not successful in climbing the ladder. Dr. Caswell cited a case study in which in 1909 some cities had as many as 30 per cent of all children repeating grades, that there were pupils 15, 16, 17 years of age in the first, second, and third grades. This raised the question, "whether a ladder constructed with year-by-year steps was one that the large group of children with tremendous differences in ability could successfully climb."

According to Dr. Caswell, "Scientific studies revealed some highly important facts, many of which were contrary to popular belief. For example, many studies reported that when there is question about failing or promoting a child, the odds are overwhelming that his achievement will be greater the next year if he is promoted than if he is failed. . . . Findings such as these raised this kind of question: Is it better for a pupil who has been in school 7 years to be in the fourth grade achieving at the fourth-grade standard or to be in the seventh grade achieving at the fifth-grade standard?"

"The result of a whole series of studies and experiments was an extension of the concept of equality of educational opportunity. Equality, it was agreed, should not mean identical opportunities but quite the opposite; that is, each individual should be afforded the educational opportunity that is best adapted to his particular needs and abilities. The standard to be applied under this concept is whether the individual is achieving as much as he can."

Dr. Caswell pointed out that, "One qualification of the concept of standards I have presented needs always to be kept in mind. That is, that it applies only to general education. When it comes to professional preparation and other types of specialization, the nature of the task to be done and of the subject matter required imposes certain essential standards. In brief, in educating a man to be a citizen it is a good investment to make him the best citizen possible in terms of the capacities he possesses, but if he is being educated to be a surgeon it is not enough that he do as well as his ability permits; he must be able to save a reasonable proportion of his patients. He has to be a citizen for better or for worse, but he does not have to be a surgeon."

Dr. Caswell also mentioned that the old concept of grade standards focuses attention on the student with low achievement. As a consequence teachers are constantly striving to improve the records of slow-learning students with the possibility that a program that would challenge gifted children is being overlooked.

Dr. Caswell feels that standards of achievement measured grade by grade tend to lead down the road to a selective educational system, whereas standards that are set for each pupil in relation to his own capacity continue development of a program based on the principles of equality of opportunity.

**H. L. Caswell (right), this year's Steinmetz Memorial Lecturer, is greeted by Vice-Chairman H. C. Anderson of the Schenectady Section before a portrait of Dr. Steinmetz. Dr. Caswell is holding the book presented to him in appreciation of his lecture**

### METHODS OF TEACHING

In answer to the criticism that American schools have "gone soft," Dr. Caswell cited examples whereby students tend to learn more when they do things that are interesting to them than when they are required to do subject work that is distasteful to them. The old concept of learning mathematics to develop an analytical mind, that the harder a subject was the better material it was for learning, and that memorizing of spelling lists would develop a person's ability to remember information in other subjects now gives way to the newer concept that the best way to achieve a goal is to go at it directly. "Thus, it became clear that Latin is all right to teach the structure of language, and mathematics is essential to keeping one's accounts or building a bridge, but if you want people to understand social problems, then teach them about social problems, and if you want them to understand family relations, teach them about family relations."

Interest was essential to continued effort on the part of the pupil to learn new things. A pupil could be forced to study a subject, but if he found it distasteful, he would drop it the moment the pressure was relaxed. "Thus, it became evident that often the main thing pupils were taught was to dislike what they were studying."

Another aspect of the old conception of learning was great faith in memorization. Dr. Caswell showed that knowledge of facts does not lead to a desirable behavior. "A student might be able to recite all the facts about the structure and processes of government but that did not mean at all that he would vote when he came of age or that he would be a good citizen generally."

Dr. Caswell cited cases where students educated under the newer method of teaching were tested with information that had been used with children back in 1845 and found that the children in 1845 made four times the number of mistakes in spelling made by present-day children, even though many of the words were in much more common usage then. The reports show that the newer methods of learning are quite superior to the older ones.

Dr. Caswell stated further: "Thus, the

critics of modern methods of teaching are really attacking a conception of the psychology of learning and its application to teaching which grew out of a mass of research and study extending over a half century. Their criticisms do not relate primarily to a few extreme and esoteric theories but to a development which is one of the distinctive characteristics of the program of American schools. There is still great possibility of improvement in teaching, but the way to achieve this is not to discard new methods in favor of old. Rather it is to get more and more teachers who still use old methods well enough trained to use the new. At the same time it is essential that research be continued to discover still better procedures."

EDUCATION AND RELIGION

Dr. Caswell said that "a considerable number of religious leaders feel that inadequate attention is given in the public school program to religion."

Dr. Caswell retraced the history in our educational system on this particular point and showed that in colonial America the typical European pattern was followed in which church and state were partners in the maintenance of an established religion, and schools were a major concern of the church. He further stated that: "This situation was changed substantially when the concept of separation of church and state, which had previously been a minority view, was written into our Constitution as the First Amendment." He cited that in 1837 the issue between nonsectarian and religious education was sharply drawn. Horace Mann, the first Secretary to the Board of Education in Massachusetts, was the leader of the nonsectarian educational groups, and he was soon attacked with great vigor by religious leaders.

Dr. Caswell showed that the solution was a distinctive American development. Dictated by two dominant national concerns, it resolved itself into the establishment of public schools for all individuals under a single system and, on the other hand, the opportunity for the establishment of private schools with the requirement that they meet the minimum State educational standards. Dr. Caswell felt that public schools of this country have been a tremendous power for good. "Over the years they have been the community agency that has most consistently brought together pupils of all classes and religious beliefs. . . . If the thousands upon thousands of immigrant families who poured into this country had sent their children to parochial schools, each with others of their own faith, I believe it would have slowed their assimilation immeasurably."

Dr. Caswell summarized his point by stating that "the basic need for a single publicly supported school system to foster national unity recognized a century and more ago exists today every bit as much as it did then." Feeling that our people still differ tremendously on religion, Dr. Caswell felt that it would be impossible to teach religious beliefs without violating the conscience of some parents. He felt that this is an area in which it would be easy for the majority of parents to infringe on the religious freedom of the few. Summarizing, Dr. Caswell stated that: "Looking to the future, it seems to me we should seek in every possible way to preserve the plan which was developed during the public school awakening and which on the whole has worked remarkably well. In my judgment it will continue to work effectively so long as the following conditions prevail: first, that the large majority of people representing all classes and groups choose to send their children to public schools; second, that minorities who so desire may freely send their children to private schools; third, that public funds are used only to support public schools; fourth, that instruction bearing on religious beliefs is not injected into the public school curriculum but is left to the home and the church; and fifth, that the public schools give appropriate emphasis to the common moral values in our culture."

Dr. Caswell concluded: "I return to the theme with which I opened: many of the critics are not attacking just extreme and fringe aspects of the program of public education; they are striking at basic and distinctive characteristics. There are no more central and important features of the program of American schools than our concept of equality of educational opportunity, the way in which modern methods of teaching have been developed out of research on learning, and our solution of the relation of religion and education. Yet current criticisms involve all of these."

"At no time since the days of Horace Mann and Henry Barnard, in my opinion, has there been such widespread consideration of basic educational issues. This period will involve fateful educational decisions which might well result in major changes in the course of our educational development. In my view it may appropriately be characterized as 'The Great Reappraisal of Public Education.' "

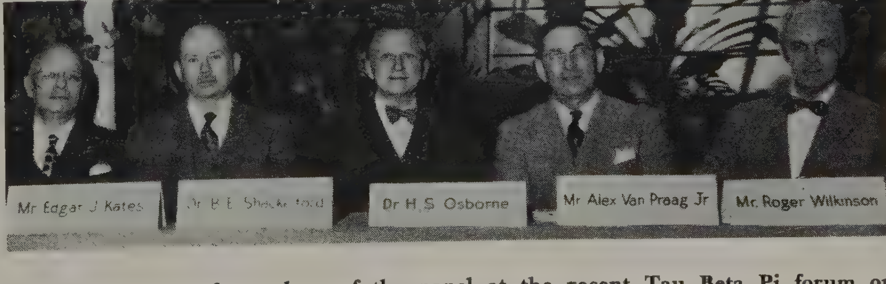
Mr. Garr, in appreciation for his excellent presentation, presented to Dr. Caswell a leather-bound book showing photographs of the life of Charles Proteus Steinmetz with various historical comments incorporated therein. After receiving the gift, Dr. Caswell answered questions from members of the audience.—*A. E. Bell, AIEE Schenectady Section.*

# Tau Beta Pi Forum Considers the Unity of the Engineering Profession

The New York Alumni Chapter of Tau Beta Pi, meeting at the Hotel Astor on April 28, 1952, held a forum on the subject "Unity of the Engineering Profession." Dr. H. S. Osborne, chief engineer of the American Telephone and Telegraph Company and secretary of the Exploratory Group to Consider Increased Unity in the Profession, acted as moderator. The four panel members were: E. J. Kates, consulting engineer, who represented The American Society of Mechanical Engineers (ASME) in the Exploratory Group; Dr. B. E. Shackelford, Radio Corporation of America, who represented the Institute of Radio Engineers (IRE) in the Exploratory Group; Alex Van Praag, Jr., Warren and Van Praag, Inc., who represented the National Society of Professional Engineers (NSPE) in the Exploratory Group; and Roger Wilkinson, past chairman of the Conference of Professional Technical Personnel of the Bell Telephone Laboratories.

Dr. Osborne outlined the history of the movement to unify the engineering profession. In 1949, the Engineers Joint Council (EJC) invited 16 national engineering societies to designate representatives to form an Exploratory Group which would discuss and recommend means for increasing the unity of the engineering profession. Dr. Osborne pointed out that the approach was unity of the profession which leads to particular emphasis on responsibility of engineers to serve their fellowmen, rather than in the manner of a labor union or other collective bargaining unit. Through greater unity it is believed the engineers can better serve their fellowmen, their country, and themselves.

The Exploratory Group evolved four plans of action, designated *A*, *B*, *C*, and *D*. The group voted to recommend Plan *A* as an initial step and the most feasible proposal for getting a unity organization launched at this time, this step to be followed at once by other steps, and has recently issued a report summarizing its conclusions (*this issue, pp 588–94*). Plan *A* contemplates expansion of the EJC to admit to membership all 15 of the engineering societies which participated in the Exploratory Group studies. Thus the plan, if adopted, would not start unifying the profession "from scratch," but will take advantage of the co-operative organization already existing in the EJC. The unity organization, while initially controlled by the member societies, would immediately




**The moderator and members of the panel at the recent Tau Beta Pi forum on "Unity of the Engineering Profession"**

study the best form and type of individual memberships and membership of local and regional engineering groups.

Mr. Kates expressed his strong approval of the plan recommended. All proposed plans have had a considerable amount of "grass roots" discussion among ASME members; the results of their discussions after meetings of local sections, geographic regions, and the national convention showed this society to be strongly in favor of the plan to enlarge Engineers Joint Council. Mr. Kates pointed out that the effectiveness of EJC has been demonstrated and cited some recent accomplishments. For example, while engineering has not always been considered as a profession on the level of the legal and medical professions by the United States Government, today, partly through the efforts of the EJC, the professional status of engineering has been greatly strengthened by inclusion of appropriate references to the profession in labor, civil service, and military legislation.

Expansion of the EJC from its present membership of five societies to include all 15 societies of the Exploratory Group, according to Mr. Kates would increase the membership behind the unity organization from the 135,000 now in the EJC societies to a total of 215,000. The basic requirement for success in carrying out any plan of unification is the enthusiastic support by a large number of engineers, including adequate financial support. It should be stressed that the proposed plan is only an initial step, many problems remaining for early solution. One major outstanding problem is that of individual membership. The proposed plan contemplates future study of these problems and for the further development of the plan in any direction desired.

Dr. Shackelford reported that the Institute of Radio Engineers has not yet been able to decide on the proposed plan. Before going ahead with any plan, such questions as the following should first be clearly answered: What is "unity" and why do we want it? Is the purpose of unity primarily to enhance the social standing of engineers, or to increase their earning power? Is the purpose to aid the engineer as an individual, or to aid society as a whole? Would it be better for the unity organization to be controlled by the various engineering societies, or in the charge of the engineers as individuals?

Until these questions are resolved, the IRE feels unable to give wholehearted support to Plan *A*. Dr. Shackelford stressed that IRE affairs are conducted by its individual members with no regard for corporation managements. Few members of IRE are licensed engineers, while many are physicists, chemists, and so forth, and may not always share the same interests as the engineers. While it may be timely to proceed with the Plan *A* as recommended and try to make the most of it, it is important ultimately that the control of the unity organization rest in the hands of the individual engineers.

Mr. Van Praag expressed disfavor with Plan *A* in which EJC would be expanded to include all the national societies, on the grounds that there is not as yet enough agreement among the interested parties to warrant embarking on a unity program. The principal disagreement at present is as to whether there should be a loose-knit co-operation of the societies, per Plan *A*, or whether the individual engineers should be organized into, and pay dues to, a new society to be patterned after the NSPE. This latter would be similar to Plan *D* which was supported by the NSPE. Mr. Van Praag pointed out that Plan *A* proposes in effect that the 15 societies of the Exploratory Group take over the identical professional development field which the NSPE has been successfully cultivating since 1934. The NSPE now has 27,000 members in all branches of engineering in every state, and is one of the fastest growing of the major national societies.

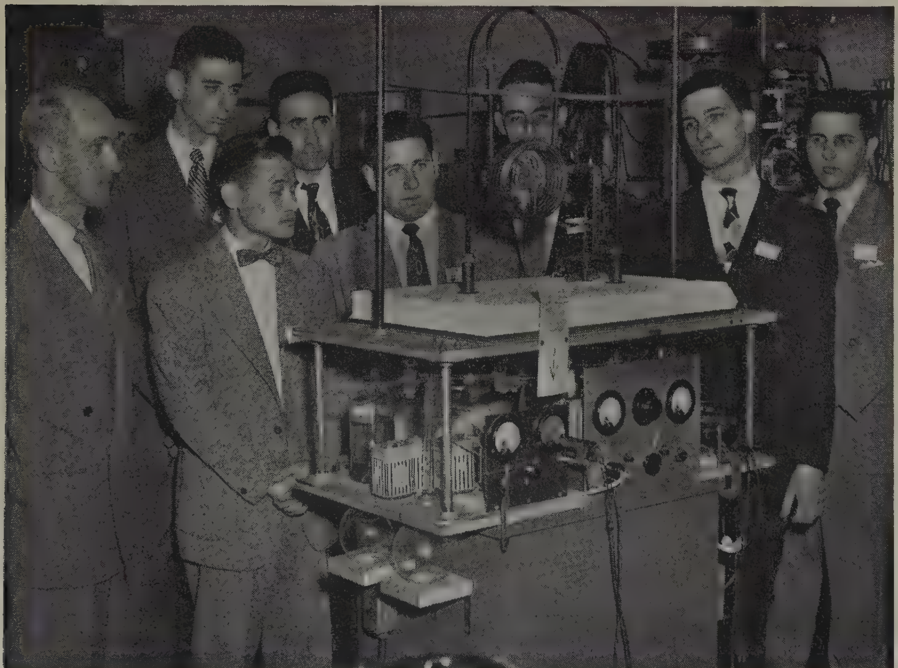
In successful forms of business, such as corporations, the individual stockholder contributes his money and expresses his views through his voting power. By analogy, Mr. Van Praag argued, the unified engineers' group would be the most successful if the individual engineers were to pay dues and express their views through their voting powers. Thus each engineer would have an individual interest in the unity organization. It was principally this lack of specific provision for individual dues-paying memberships that caused the AIEE to reject the Exploratory Committee's Plan *A* proposal. (Under Plan *A* it is assumed that the various societies would financially support the unity organization.)

Mr. Van Praag stated his firm belief that among the representatives on the Exploratory Group, there was very much less unanimity of sentiment for Plan *A* than was expressed by the vote at the December 15, 1951, meeting of the Exploratory Group. The AIEE is the only society which has conducted an individual membership poll bearing on the subject of what kind of a unity organization and program they would find acceptable; NSPE has come the next closest to this procedure. The individual members should be supreme in deciding this matter of unity, rather than the boards of directors of the national technical societies.

Mr. Wilkinson stated that the majority of engineers are perfectly happy to leave the technical society management in present hands, namely, the higher brackets of engineering management and the deans and department heads at our universities. However, since 75 per cent or more of the 400,000 engineers in the country are employees in the nonsupervisory class, they would pretty surely disapprove (if given the opportunity to vote on the matter) of placing their nontechnical, or professional, interests solely in the hands of the technical society leaders. Instead, a unity organization should be made up of representatives of all groups in the profession, nonsupervisory and management, younger and older men, and chosen from all branches of engineering.

Mr. Wilkinson showed graphically the extent of technical and professional activity

# Student Winners View Electronic Research



**Winners in the AIEE Student Prize Paper Contest examine laboratory apparatus for the study of molecular properties of gases at the David Sarnoff Research Center of the Radio Corporation of America, Princeton, N. J. Representing colleges and universities in the northeastern United States (AIEE Districts 1, 2, and 3), the visiting prize winners are, left to right, D. J. Glick, Lehigh University; M. M. Dickinson, Jr., Worcester Polytechnic Institute; J. Y. F. Ng, Carnegie Institute of Technology; M. J. Bentivegna, Newark College of Engineering; S. D. Kahn, Rensselaer Polytechnic Institute; R. J. Farrelly, Manhattan College; M. C. Baum, New York University; J. V. Reihing, Jr., University of Pennsylvania. The tour took place on May 16, 1952**

among the various engineering societies. The so-called professional interests include:

1. Service to society.
2. Protection of the public.
3. Expression of the engineers' viewpoint on appropriate matters.
4. Advancement of engineering education in all its phases.
5. Continued development of graduate engineers.
6. Increase of engineers' prestige and esteem in the public eye.
7. Economic welfare of engineers.
8. Co-operation with other professions.

Of these professional interests one of the most important these days in the eyes of the ordinary engineer is his deteriorating economic status. This is evidenced by the rapid growth of nearly 70 engineering and scientific employees associations over the country in the last 6 or 8 years. About 25,000 engineers are already in groups certified for bargaining purposes by the National Labor Relations Board. Thus, any unity organization which seeks to enlist the enthusiastic support of employee engineers comprising three-fourths of the profession must genuinely interest itself in problems of satisfactory remuneration, as well as the other professional interests.

Mr. Wilkinson urged that the Exploratory Committee resume its deliberations augmented by representatives of employee engineer groups, either as delegates or advisors, to see whether a strong and democratic unity organization cannot be devised which will appeal to the great majority of the engineering profession.

It was the sense of the meeting that the open debate of conflicting views had been extremely informative to all those present, and the hope was expressed that other similar meetings might be held in the future before other groups, to help clarify the programs for engineer unification and aid in molding one for the best interests of engineers and society. This discussion confirms the fact that the majority of engineers definitely desire a unified organization and that it is essential that the differences in points of view as to how this organization is to be formed be reconciled.

Elies Elvove, president of the New York Alumni Chapter of Tau Beta Pi, served as chairman of the meeting and introduced the moderator and members of the panel.

# AIEE Board of Directors Holds Regular Meeting in St. Louis

The regular meeting of the AIEE Board of Directors was held in the Jefferson Hotel, St. Louis, Mo., on April 17, 1952.

The following resolutions were adopted in memory of Past-Presidents Blake D. Hull and Ralph D. Mershon, both of whom died on February 15, 1952:

*Resolved:* That, upon behalf of the membership of the American Institute of Electrical Engineers, the Board of Directors hereby expresses its profound sorrow and regret at the death of Blake D. Hull, who had been a Vice-President, a Director, and finally President of the AIEE during the year 1947–48, and who for more than 30 years was an active and distinguished participant in Institute affairs; and, that the Board hereby extends its sincere sympathy to the members of his family.

*Resolved:* That, upon behalf of the membership of the American Institute of Electrical Engineers, the Board of Directors hereby expresses deep regret at the death of Ralph Davenport Mershon (AM '95, M '96, F '12), Director 1900–03, Vice-President 1903–05, President 1912–13, and an outstanding leader in high-voltage power transmission; and extends sympathy to the members of his family.

The Board adopted a resolution of appreciation of the services of Treasurer W. I. Slichter, who will retire as treasurer the end of the present administrative year, to be presented to him in the form of a scroll at the Annual Meeting of the Institute in June.

Executive Committee actions on membership applications were reported and confirmed, as follows: As of February 28, 1952—17 applicants transferred and 4 elected to the grade of Member; 2 Members reinstated; 203 applicants elected to grade of Associate Member; 1 Associate Member reinstated; 12 applicants elected to grade of Affiliate; 282 Student members enrolled. As of March 27, 1952—1 applicant transferred to grade of Fellow (under old requirements); 23 applicants transferred and 2 elected to the grade of Member; 226 applicants elected to the grade of Associate Member; 36 applicants elected to the grade of Affiliate; 179 Student members enrolled.

Recommendations adopted by the Board of Examiners at meetings held on February 21 and March 20, 1952, were reported and and approved. The following actions were taken, upon recommendation of the Board of Examiners: 41 applicants were transferred to the grade of Member; 1,974 applicants were elected to the grade of Associate Member.

Upon proposal, approved by the Board of Examiners, the Board voted to invite L. W. Birch to become a Fellow of the Institute.

FINANCES

Chairman Barrett of the Finance Committee reported disbursements from general funds as follows: February, $79,166.03; March, $77,043.12.

Technical conference loans since the January Board meeting were reported by Mr. Barrett, as follows: $200—Conference on Problems in the Rubber and Plastics Industry, Akron, Ohio, April 28, 1952; $300—Conference on Telemetering, Long Beach, Calif., August 26–27, 1952; $250—Conference on Progress in Quality Electronic Components, Washington, D. C., May 5–7, 1952.

Mr. Barrett reported receipts to March 31, 1952, amounting to 34.7 per cent of the estimated receipts of $959,500 for the appropriation year which began October 1, 1951 (corresponding figure last year was 31 per cent), and expenditures to March 31 amounting to 50.3 per cent of the estimated expenditures, $971,210, for the appropriation year.

The following resolution was adopted, upon recommendation of the Finance Committee:

*Resolved:* That the names of members in arrears on May 1, 1952, for dues of the fiscal year which began May 1, 1951, be removed from the active membership list, as required by the Institute Bylaws, and that the time for the payment of such dues be extended until further action by the Board of Directors.

The Board voted that the regular travel allowance be made available to the chairman of the Committee on Student Branches for attending the Winter and Summer General Meetings, instead of the present allowance for attending each District Conference on Student Activities.

ACTIONS AND APPOINTMENTS

The Board voted that greetings in the form of a scroll, on the occasion of the 100th anniversary of the American Society of Civil Engineers, be prepared and presented to the society at the Centennial of Engineering Convocation to be held in Chicago, Ill., on September 10, 1952.

A resolution was adopted setting the time and place of the Annual Meeting of the Institute as Monday, June 23, 1952, in Minneapolis, Minn.

The Board confirmed the appointment by the President of the Committee of Tellers, as follows, to count and report on the ballots cast in the election of Institute officers and the ballots on the proposed amendments to the Constitution: Warren H. Bliss (*Chairman*), P. W. Austin, C. F. De Sieno, E. E. Katibah, Leland L. MacDonald, A. J. Prier, Andrew Spiak.

Past-President Everett S. Lee was nominated for appointment to the Advisory Committee on Technological Information, Atomic Energy Commission, to succeed Editor Charles S. Rich.

Upon invitation, the Board nominated a candidate for the Standards Medal and candidate for the Howard Coonley Medal, both awarded by the American Standards Association.

The Standards Committee reported approval of the following Standards:

Revision of Switchgear Assemblies and Enclosed Bus, Standard *27*

Revision of "Recommended Practice for Electric Installations on Shipboard," AIEE Standard *45*

Recommended Practice for Measurement of Field Intensity Above 300 Megacycles From Radio-Frequency Industrial, Scientific and Medical Equipment, AIEE Standard *950*

The Standards Committee reported the appointment of the following representatives on standardizing committees:

Electrical Standards Committee, American Standards Association (ASA): R. D. deKay, alternate, to succeed C. M. Gilt, resigned

United States National Committee of International Electrotechnical Commission (IEC): R. D. deKay, alternate, to succeed C. M. Gilt, resigned

Mining Standardization Correlating Committee,

# Richland Section Awards Student Prize

**Orville Campbell (left), senior in electrical engineering at Washington State College, receives Student Papers Contest award from R. B. Crow, chairman of the AIEE Richland Section, at a meeting on May 9, 1952. The title of the prize-winning paper was "Sectional Paper-Machine Drive Amplidyne Control"**

ASA: A. C. Muir, representative, reappointed; F. C. Nicholson, alternate

Sectional Committee *C19*, "Industrial Control": K. W. John, representative, to succeed Gordon Thompson, resigned; J. A. Cortelli, alternate

Sectional Committee *C34*, "Mercury Arc Rectifiers": L. W. Morton, representative

Sectional Committee *C35*, "Rotating Electric Machinery on Railway Locomotives and Rail Cars and Trolley Gasoline—Electric and Oil Electric Coaches": K. H. Gordon, chairman of sectional committee

Sectional Committee *C37*, "Power Switchgear": L. R. Gaty, representative, to succeed G. Sutherland, resigned

Sectional Committee *C61*, "Electric and Magnetic Magnitudes and Units": J. B. Russell, representative, to succeed W. I. Slichter, resigned; J. J. Smith, representative

Sectional Committee *C62*, "Lightning Arresters": H. R. Stewart, chairman of the sectional committee and of the AIEE delegation; W. A. McMorris, representative

Sectional Committee *C64*, "Carbon, Graphite, and Metal-Graphite Brushes": H. F. Brown, representative, to succeed S. Withington, resigned

Sectional Committee *J6*, "Rubber Protective Equipment for Electrical Workers": J. J. Pokorny, representative, to succeed H. S. Vassar, deceased

Sectional Committee *M24*, "Electric Equipment in Coal Mines": A. B. Chafetz, chairman AIEE delegation; C. L. Gust, representative; C. O. Wood, representative

Sectional Committee *Y1*, "Abbreviations": H. P. Westman, representative

Sectional Committee *Z17*, "Preferred Numbers": H. P. Westman, representative

Sectional Committee *Z48*, "Marking of Compressed Gas Cylinders to Identify Content": H. R. Harris, representative

Joint AIEE-Edison Electric Institute-National Electrical Manufacturers Association Committee on Basic Impulse Insulation Levels: H. W. Collins, representative, to succeed R. T. Henry, resigned; J. M. Towner, alternate

Joint AIEE-NEMA Committee on Textile Mill Control Enclosures—Approval of formation of committee and of AIEE representatives: I. S. Bull, chairman of delegation; S. O. Cowan; C. F. Hedlund; J. T. Meador; J. D. McConnell

The following resolution was adopted:

*Whereas* it has been apparent for many years that the present headquarters building on West 39th Street, New York, N. Y., is inadequate to meet the needs of the Founder Societies, and

*Whereas* for several years past efforts have been made to interest various possible donors in contributing substantial amounts of money to finance a new headquarters building without success,

*Now therefore be it resolved* that it is the opinion of the Board of Directors of the American Institute of Electrical Engineers that United Engineering Trustees should be urged to consider promptly, and to submit to the other Founder Societies for their consideration, a plan for raising the additional funds required over and above the assets of United Engineering Trustees available for the purpose, by means of contributions from the reserve funds of the Founder Societies and of other engineering societies that might join in the project, with the understanding that if favorable consideration of this plan would make available a large part of the required additional funds, the balance would be solicited in the form of contributions from individual members of the interested societies or other sources, and

*Be it further resolved* that a copy of this resolution be forwarded to United Engineering Trustees.

The following actions concerning meetings were taken upon recommendation of the Committee on Planning and Co-ordination:

Dates of the 1953 Summer General Meeting in Atlantic City, N. J., were changed to June 15–19

Dates of the 1953 Pacific General Meeting in Vancouver, British Columbia, Canada, were changed to September 1–4

Authorized the holding of the 1953 Fall General Meeting in Kansas City, Mo., November 2–6

Authorized holding the 1955 Winter General Meeting in New York, N. Y., January 31–February 4.

Upon recommendation of the Committee on Planning and Co-ordination, the Board voted to request the Committee on Constitution and Bylaws to prepare for submission to the membership a proposed amendment to the Constitution which would change the membership of the Nominating Committee to include one representative of each geographical District elected by its executive committee, one representative of each technical division elected by the division committee, and other members chosen by and from the Board not exceeding in number the number of technical divisions.

A brief report was presented of a reorganization meeting of the United States National Committee of the World Power Conference held on March 18, 1952. At this meeting, it was voted that the reorganized National Committee shall elect an Executive Board consisting of seven members, in addition to the chairman and vice-chairman, including representatives of three groups: (*a*). selected professional engineering societies; (*b*). selected associations of industrial and other groups; and (*c*). selected officials of the Federal Government. Upon request that the AIEE appoint a representative and an alternate from among its present or past officers, it was voted that the President be empowered to make such appointments.

An invitation from the Société Française des Electriciens to nominate a national candidate for the Mascart Medal, was referred to the chairmen of the Edison Medal and Lamme Medal Committees.

Following the suggestion of Vice-President Purnell that provision be made for the appointment of liaison representatives of the Institute in countries having small numbers of members but no Local Honorary Secretaries, it was voted that the policy for the appointment of Local Honorary Secretaries be amended to provide for the appointment of a Local Honorary Secretary in any country where a desire for one is expressed by AIEE members.

ATTENDANCE

Present at the meeting were: *President* F. O. McMillan; *Vice-Presidents* H. R. Fritz, N. M. Lovell, J. A. McDonald, F. W. Norris, J. R. North, C. S. Purnell, J. C. Strasbourger, J. G. Tarboux; *Directors* Walter J. Barrett, F. R. Benedict, R. F. Danner, D. D. Ewing, C. W. Fick, A. H. Frampton, M. D. Hooven, Elgin B. Robertson, Herbert J. Scholz, Victor Siegfried; *Secretary* H. H. Henline; by invitation, D. A. Quarles, nominee for President, and C. M. Lytle, nominee for Vice-President, District 7.

## AIEE Great Lakes District Reports on Student Activities

The AIEE District 5 (Great Lakes) Student Activities Committee meeting and student papers competition were held May 9–10, 1952, at the Michigan College of Mining and Technology, Houghton. A total registration of 150 included representation from 20 Student Branches.

The sessions opened with the under-

graduate papers competition, at which Professor E. A. Reid, District chairman, introduced the student chairman of the University of Iowa, Gary Moon, who presided at the morning session. Sixteen papers from 16 Branches were presented at this, and at the afternoon session which was presided over by the Illinois Institute of Technology student chairman, J. W. Scheck. Following the session, an inspection trip was made to the Arcadia tourist mine.

More than 200 persons attended the Student Branch Conference banquet which was held in the evening with Professor G. W. Swenson, counselor of the host Branch, as toastmaster. The welcome was extended by Dr. G. C. Dillman, president of the Michigan College of Mining and Technology, after which an address, "Facing New Horizons," was presented by J. H. Warden, Upper Peninsula Power Company. The talk was followed by a movie entitled "Quality Control From Ore to the Finished Product" by the Calumet and Hecla Consolidated Copper Company.

Following the banquet, a meeting of the District Committee on Student Activities, with E. A. Reid as chairman, took place. Professor E. L. Fairchild, Wayne University, opened a discussion on the desirability of obtaining a larger amount of financial help for Student Branches from headquarters, and it was decided to present a request to this effect at the Summer General Meeting in Minneapolis, Minn. Other actions included the election of Professor Fairchild as junior vice-chairman of the officers committee, and a discussion of District rules for the District 5 papers competition.

For the first time, the meeting this year included a separate meeting of the incoming Student Branch chairmen. It was presided over by P. C. Lee of the University of Illinois. A business meeting of the Branch counselors and the Student officers also was held, with Mr. Reid presiding. At this meeting, much interest was shown in a proposal for a new AIEE publication at the student level, and it was moved to contact headquarters in regard to the establishment of a student magazine.

After the luncheon that followed, Vice-President J. R. North announced the winners of the prize paper competition:

*Undergraduate Papers*

First Prize: "Report on Design of an Electronic Pulse Generator for Physiological Research," Richard F. Grentges, University of Minnesota

Second Prize: "An Electronic Simultaneous Equation Computor," Donald J. Niehaus, University of Detroit

Third Prize: "A Practical Means of Pictorial Representation of Combustion Chamber Pressure," Harry H. Davis, Purdue University

Honorable Mention: "The Use of the Ring Demodulator With Signals Involving Alternating Component and a D-C Level," William D. Ball, Michigan State College

*Graduate Papers*

First Prize: "Polystable State Multivibrators," Richard M. Weissman, Illinois Institute of Technology

Second Prize: "A New Method for Accomplishing Speed and Slip Measurement of Rotating Machines," W. B. Swift, University of Wisconsin

## Additional Names Announced to List of Members for Life

Membership for life is granted by the AIEE to members who either have paid annual dues for 35 years, or have reached the age of 70 and paid dues for 30 years. A list of those who have become Members for Life during the preceding year is published annually in *Electrical Engineering*. Institute members enrolled as Members for Life as of May 1, 1952, are

Adams, C. C.
Alger, P. L.
Ambuhl, F. F.
Andrews, H. L.
Arland, F. L.
Asset, H. L.
Bailey, R.
Bartmess, M. W.
Beatty, L. B.
Berkshire, W. T.
Bessesen, B. B.
Blackwood, W. C.
Booth, J. J.
Bowles, R. H.
Brinkmeier, A. E. H.
Brockway, R. M.
Brown, G. J.
Brown, R. E.
Bryans, H. B.
Bullard, W. R.
Burgess, H. O.
Burnap, R. S.
Butcher, W. F.
Byng, E. S.
Callard, N. H.
Carver, H. E.
Charlesworth, H. P.
Chitty, A. M.
Clements, C. H.
Clokey, A. A.
Cole, H. L.
Cooper, S. M.
Coover, M. S.
Crosby, L. S.
Culver, C. A.
Curry, W. A.
Curtis, R. E.
Cutting, F.
Dalton, F. K.
Davis, A. L.
Day, B.
Deans, W.
Delehanty, W. J.
Diehl, G. S.
Dunlap, C. H.
DuVall, W. C.
Edison, O. E.
Ellis, J. W.
Eshbach, O. W.
Farmer, T. O.
Fick, C. W.
Field, E. L.
Fitz, E. S.
Fraser, J. W.
Gambrill, W. N.
Garlington, A. C.
Garrett, A. M.
Goetzenberger, R. L.
Goldthwaite, G. E.
Grah, M. E.
Grigsby, B. J.
Hacking, J.
Hanff, E. A.
Hagensick, E. H.
Hague, A. E.
Haines, L.
Haines, W. H.
Hale, G. R.
Hansen, K. L.
Harbaugh, W. M.
Harris, C. R. R.
Heath, L. A.
Heidenreich, A. H.
Herrick, D. C.

Kistler, R. E.
Kleinschmidt, E. E.
Knowles, W.
Knowlton, A. E.
Kortheuer, H. F.
Kositzky, G. A.
Kraft, C. H.
Krug, F.
Kuhn, G. W.
Kurtichanof, L. E.
Kurtz, W. O.
Lindridge, C. D.
Lord, M. G.
Lovell, W. V.
Lytle, J. H.
MacCallum, A. F.
MacDonald, W. G.
Malott, C. G.
McCarn, G. E.
McLagan, E. G.
Meissner, E. B.
Mertz, K. J.
Metzenheim, H. H.
Meyer, W. E.
Molina, E. C.
Moore, D. H.
Moore, E. E.
Moren, W. H.
Morgan, N. L.
Morrow, L. O.
Morse, R. E.
Munroe, H. K.
Myers, A. M.
Nash, J. F.
Nelson, A. L.
Nikiforoff, B.
Oster, E. A.
Peebles, J. B.
Perley, F. G.
Perry, L. P.
Prince, D. C.
Putnam, W. J.
Ray, A. W.
Regal, A. P.
Ricketts, F. E.
Ritter, R. W.
Roberts, E. A.
Robertson, A. S.
Robinson, G. D.
Ross, J. H.
Russell, E. G.
Schwarting, H. F.
Seeger, E. W.
Service, J. H.
Shafer, W. L.
Shaw, A. M. T.
Shuck, G. R.
Shurts, G. J.
Shute, E. R.
Silva, A. D.
Sloan, R. D.
Snider, G. E.
Snow, L. D.
Speer, G. F.
Spence, J.
Sprenger, G. W.
Staehle, P. M.
Steele, E. H.
Stokes, S.
Stone, E. C.
Stone, R. R.
Story, E. C.
Swift, G. W.
Taylor, A. M.

Hill, C. G.
Holtz, F. C.
Honaman, R. K.
Horelick, S.
Howard, D. G.
Huff, E. L.
Hulse, G. E.
Jack, H.
Jackson, W. A.
Janson, G. W.
Johnson, H. A.
Jones, C. G.
Jones, C. R.
Kent, P. J.
Kerr, H. H.
Kester, H. J.
Kierstead, F. H.
Kilby, H. S.
Kirchner, H. P.

Taylor, D. W.
Temme, A. M.
Templin, J. R.
Thomas, J. E.
Treat, R.
Trueblood, H. M.
Van Nieukerken, J. M.
Vinal, G. W.
Vincent, G. I.
Wallace, G. S.
Weyman, H. E.
White, E. J.
Whitsit, L. A.
Wildes, K. L.
Wilkins, R.
Winne, H. A.
Wiseman, R. J.
Wolf, H. C.
Yoe, H. A.

## ECPD Meeting Scheduled During Engineering Centennial

The 20th annual meeting of the Engineers' Council for Professional Development (ECPD) will be held September 5–6, 1952, at the Hotel Sheraton, Chicago, Ill. This meeting has been scheduled as part of the Centennial of Engineering.

Hotel reservations should be placed at once. Should accomodations be unobtainable at the Hotel Sheraton, information about rooms at nearby hotels may be obtained from ECPD headquarters at 33 West 39th Street, New York 18, N. Y.

## Quarles Addresses New Mexico Engineering, Technical Council

On May 12, 1952, the AIEE Northern New Mexico Section sponsored a meeting of the Council of Technical and Scientific Societies in Albuquerque, N. Mex. Featured at the meeting, which was held at the Science Lecture Hall of the University of New Mexico, was an address by D. A. Quarles, president of Sandia Corporation and AIEE president-elect for 1952–53. Mr. Quarles considered the question: "What Can an Engineer Expect From a Professional Organization?"

The Council of Technical and Scientific Societies is an organization formed for the purpose of co-ordinating the activities of such societies in Albuquerque in relation to those matters of professional, educational, or public nature which are beyond the scope of activity of the individual societies or which can be performed more effectively by co-operative action.

**Chairmen of member societies of the Council of Technical and Scientific Societies of Albuquerque are shown, left to right: H. C. Biggs, AIEE; J. F. Durrie, American Society of Tool Engineers; H. H. Patterson, Sandia Base Radio Club; D. A. Quarles, AIEE president-elect and speaker; J. L. Hollenbeck, Instrument Society of America; C. H. De Selm, American Society of Mechanical Engineers; B. J. Bittner, Institute of Radio Engineers**

**J. O. Leslie, Lehigh Valley Section chairman, welcomes Dr. E. L. Harder, who addressed the group at its annual meeting on May 9. Looking on are H. H. Angel (left), and D. A. Campbell, Jr., newly elected Section chairman**

## Lehigh Valley Section Elects Officers at Annual Meeting

D. A. Campbell, Pennsylvania Power and Light Company, will serve as chairman of the AIEE Lehigh Valley Section for the year 1952–53, beginning June 1. Mr. Campbell, who succeeds J. O. Leslie, was elected at the Section's annual meeting in Bethlehem, Pa., May 9, 1952.

Other members elected officers were: J. H. Black, A. B. Snavely, and D. O. Eschbach, Vice-Chairmen; W. C. Seymour, Secretary-Treasurer; L. F. Anderson, Manager, Williamsport Division; R. D. Evans, Manager, Wilkes-Barre Division; A. P. Lee, Manager, Easton Division; M. F. Rosol, Manager, Reading Division; C. M. Warrington, Manager, Sunbury Division.

The following managers will continue in office in their divisions to complete the unexpired year of their 2-year term: H. H. Angel, Bethlehem Division; B. B. Kern, Hazleton Division; A. W. Plonsky, Scranton Division; S. C. Townsend, Allentown Division; M. E. VanSickle, Harrisburg Division. J. O. Leslie, retiring chairman, presided at the meeting and reported on the activities of the Section during the past year.

Following the business meeting, Dr. E. F. Harder, Westinghouse Electric Corporation, spoke on "Lightning and Its Tricks." The speaker described the properties of lightning strokes and outlined the principles of lightning protection. Neil A. Fisher, Lehigh University senior, also presented a short talk.

Arrangements for the dinner and speakers were handled by H. H. Angel.

## Domestic Appliance Controls Discussed at AIEE Conference

The third annual AIEE Conference on Domestic Appliances attracted more than 160 appliance engineers to a discussion of "Domestic Appliance Controls" in Cincinnati, Ohio, May 16–17, 1952. A long-overdue interchange of technical information is now taking place among engineers in the appliance field following the well-established practices in the apparatus field. Papers were presented on most of the appliance control components, ranging from timers through thermostats, valves, solenoids, and harness connectors. Copies of these papers can be obtained from J. H. T. Miller, Secretary, Committee on Domestic and Commercial Applications; The Illuminating Company, 75 Public Square, Cleveland 1, Ohio.

So much interest has been shown that a meeting for 1953 has been arranged to take place in Louisville, Ky. The exact topic of the conference has not been selected, but it will be a $1^1/_2$-day meeting, similar to the recent one. Following the conference, there will be a conducted tour of the newly established General Electric "Appliance Park." By the time of the meeting next year, a little less than half will have been constructed, and several departments will be in occupancy.

## Recording, Controlling Instruments Will Be Subject of Conference

The AIEE Subcommittee on Electrically Operated Recording and Controlling Instruments is planning a 2-day special technical conference to be held in Philadelphia, Pa., at the Benjamin Franklin Hotel, November 17–18, 1952.

The purpose of this conference is to educate and to stimulate interest in design, theory of operation, and application of electrically operated recording and controlling instruments, to familiarize engineers with the recent advances in the metering and control of industrial processes which has been made possible largely by the utilization of new electrical recording and controlling techniques.

Conference papers on the subject should be submitted to the Technical Program Committee Chairman, A. J. Hornfeck, Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, before July 17, 1952.

# COMMITTEE ACTIVITIES

*Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

### Industry Division

**Committee on Feedback Control Systems** (*S. W. Herwald, Chairman; F. E. Crever, Vice-Chairman; A. G. Kegel, Secretary*). As the field of feedback control systems engineering has grown, its horizons have widened beyond the confines of linear systems to include systems which have more or less nonlinear components and regions of operation. Engineers are aware that not only are nonlinearities unavoidably present in physical systems, but in many cases it is possible to achieve more desirable system performance by exploiting nonlinear phenomena. Increasing demands on the performance of feedback control systems, as well as economic factors, have forced the engineer to investigate the areas outside the realm of linear behavior.

Unfortunately, the usual mathematical methods of analysis and synthesis, as used in linear systems, are not directly applicable to nonlinear systems. Although nonlinear studies have been made, both in the United States and abroad, there has not been a widespread application of this knowledge to feedback control systems engineering. The need for methods of analyzing and synthesizing systems containing nonlinearities has been voiced increasingly in recent years, particularly at conferences and technical sessions sponsored by the Committee on Feedback Control Systems.

The demand for techniques of handling nonlinear system design is being met, as evidenced by an increasing volume of technical papers on the subject. Such topics as sinusoidal analysis of discontinuous and nonlinear systems, saturation in components, the use of nonlinear components to improve system performance, and stabilization of systems operating in nonlinear regions have been investigated and reported. It is significant that an entire technical session at the AIEE Summer General Meeting in Minneapolis, Minn., was devoted to "Nonlinearities in Feedback Control Systems." Other papers and technical sessions on this important subject are planned for the future.

**Committee on Electric Heating** (*P. H. Goodell, Chairman; L. P. Hynes, Vice-Chairman; Harold Bunte, Secretary*). Interest shown at the recent Induction and Dielectric Heating Conference in Cleveland, Ohio, is prompting plans for further activities of this type by the AIEE Electric Heating Committee. Several subcommittees are now working on projects for the coming fall and winter programs. Sections interested in sponsoring papers or programs on new electric heating developments are advised to make arrangements with the committee at an early date.

Some of the projects now under way include: a Southern California Conference on Induction and Dielectric Heating for 1952; an expanded Midwestern Conference including all types of industrial process heating for early 1953; a manual with charts, nomographs, and tables on design and application data for electric heating; standards for induction and dielectric heating equipment; sponsorship of several college thesis projects and coordination on heat-transfer subjects with other technical societies.

Institute members or students who are interested in any of these projects or who wish to present material for consideration by the committee should address Harold Bunte, Secretary, AIEE Electric Heating

Committee, in care of Commonwealth Edison Company, 72 West Adams Street, Chicago, Ill.

### Power Division

**Committee on Insulated Conductors** (*C. T. Hatcher, Chairman; R. J. Wiseman, Vice-Chairman; M. H. McGrath, Secretary*). When the Insulated Conductor Committee was organized in 1947, members were selected from all groups that were interested in the manufacture and use of insulated conductors and their accessories. As indicated previously, member interest has been very high. It is felt that this interest has been maintained by providing papers at technical sessions of general interest to the membership and by holding meetings of the committee at various locations where the members could attend and participate personally in the discussions. Following this policy, a meeting of the committee was held in Montreal, Quebec, Canada, at the Mount Royal Hotel on April 16–17, 1952, in order that the Canadian members might participate more readily in the meeting. Over 60 members and guests attended, indicating that high interest is still being maintained. According to information available, it is believed that this is the first time that a technical committee has held a special meeting in Canada.

Plans are being completed for holding a symposium on the usage of aluminum for insulated conductors at the 1952 Fall General Meeting in New Orleans, La. A number of papers have been secured and it is expected that a very interesting session will materialize as a result.

Approval has been obtained for printing the papers which were presented in Cleveland on polyethylene in the form of a special AIEE publication. It is expected that this publication will be available for purchase this summer.

**Committee on System Engineering** (*R. Brandt, Chairman; H. L. Harrington, Vice-Chairman; O. W. Manz, Jr., Secretary*). For the Fall General Meeting, this committee will develop a session on load forecasting procedures. Work also is being carried forward to develop two sessions for the 1953 Winter General Meeting in New York at which the System Controls Subcommittee and the Speed Governing Subcommittee of the System Engineering Committee will jointly undertake to cover the general subject of electric system controls.

It is intended to treat the subject as broadly as possible and to cover such items as governor characteristics, generating unit and station loading practices, effects of combustion and load-frequency controls, effects of regulation on station and system economy, and so forth.

At a recent meeting in Chicago, Ill., the committee held an interesting discussion on the subject, "How Do System Planning Engineers Decide to Add Capacity in the Transmission and Distribution Plants?" The discussion covered such subjects as emergency ratings of lines and transformers; practices in allowing reserve capacity in the distribution plant; practices in allowing reserve facilities in substation and in generating stations; definitions of reserve, capacity, and capability.

### Science and Electronics Division

**Committee on Electronic Power Converters** (*I. K. Dortort, Chairman; C. R. Marcum, Vice-Chairman; J. B. Pitman, Secretary*). The committee met on January 22 in New York, N. Y., to outline plans for 1952. On May 19 and 20, 1952, a 2-day technical conference on "Electronic Converter Applications and Tubes" was held in Pittsburgh, Pa. The conference was jointly sponsored by the Subcommittee on Electron Tubes and the Committee on Electronic Power Converters. A highlight of this conference was a panel discussion on six types of rectifying devices.

The Subcommittee on Hot-Cathode Power Converters has prepared standards for hot-cathode converters and has submitted them to this committee for approval.

The publishing of the report on the survey of operation of electronic power converters has been started and copies should be available very soon.

A report on "Cooling and Corrosion Problems in Mercury-Arc Rectifiers" will be completed soon by a working group of this committee. A preliminary report on this subject was presented at the technical conference in Pittsburgh.

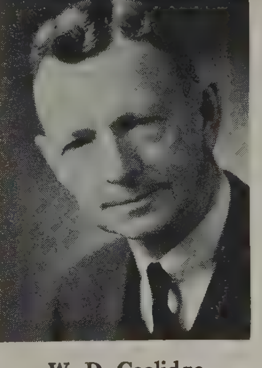
**Joint Subcommittee on Nuclear Instruments** (*G. A. Morton, Chairman*). During last summer at a subcommittee meeting, it was decided to organize a scintillation-counter symposium. Because of the interest in this field of the Bureau of Standards and the Atomic Energy Commission, and because of the assistance they could give in organizing the conference, it was decided to have these two organizations join in sponsoring the symposium. The symposium was planned for two days, January 29 and 30, 1952, at Washington, D. C. The program included 16 invited papers and approximately 25 contributed papers. The attendance was between 400 and 500, and all of those present found the symposium of considerable interest.

Because of the specialized nature of the subject, it was decided not to have another symposium the following year, but to plan them at approximately 2-year intervals.

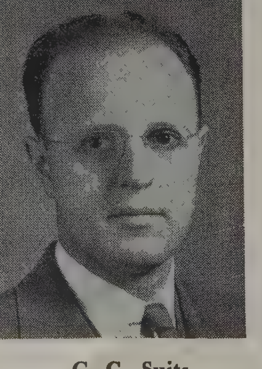
# AIEE PERSONALITIES.....

**W. D. Coolidge** (AM '10, M '34, Member for Life), consultant, General Electric Company, Schenectady, N. Y., has been named the first recipient of the K. C. Li Prize and Award for "his conception and development of a method for obtaining ductile metallic tungsten to the benefit of all mankind." The award, to be given every 2 years, was established by K. C. Li, discoverer of tungsten in China, and will be administered by Columbia University. Dr. Coolidge, former Vice-President and Director of Research of the General Electric Company, performed pioneer work on tungsten which made it possible to use this metal in incandescent lamps, radio tubes, X-ray tubes, electric contacts, and many other places. He was born in Hudson, Mass., on October 23, 1873, and received a bachelor of science degree in electrical engineering in 1896 and a doctor of philosophy degree from the University of Leipzig (Germany) in 1899. Dr. Coolidge joined the General Electric Research Laboratory in 1905 and 3 years later was made assistant director of the laboratory. He became Director of the laboratory in 1932 and remained as Vice-President of the company and Director of Research until his retirement in 1944. Since his retirement Dr. Coolidge has been consultant in X rays for the laboratory. He holds seven honorary degrees from various universities and is the winner of many awards including the Edison Medal (1927), and the Washington Award (1932). He served the AIEE on the Electrophysics (1927–29) and Edison Medal (1940–45) Committees.

**C. G. Suits** (M '41, F '47), Vice-President and Director of Research, Research Laboratory, General Electric Company, Schenectady, N. Y., has been appointed as a civilian member of the Committee on Electronics of the Department of Defense Research and Development Board, Washington, D. C. Dr. Suits became associated with the General Electric Research Laboratory in 1930, 10 years later was made assistant director of the laboratory, and in 1945 was named Vice-President and Director of the Research Laboratory. He is the author of many technical articles and is the holder of more than 60 patents. Dr. Suits is a member of the National Academy of Sciences, American Physical Society, and Sigma Xi. He is a very active member of



W. D. Coolidge



C. G. Suits

the AIEE having served on the following Institute committees: Research (1941–51, Chairman 1947–49); Technical Program (1947–49); and Award of Institute Prizes (1947–49).

**I. S. Coggeshall** (M '37, F '48), general traffic manager, International Communications Department, Western Union Telegraph Company, New York, N. Y., has been promoted to the position of Director of Planning, International Communications Department. He became associated with the Western Union Telegraph Company in 1917 as an engineering apprentice at Boston, Mass., transferring to the New York office in 1920 as engineering assistant. After holding several different administrative positions, he was made general traffic manager in 1946. During World War II he represented his company on the Cable Committee of the Board of War Communications, and had active duty assignments under the Director of Naval Communication in Washington, D. C. Mr. Coggeshall is a past president of the Institute of Radio Engineers, and has actively served the AIEE on the following committees: Communications, Technical Program, Standards, and Telegraph Systems.

**I. S. Coggeshall**

**H. S. Osborne** (AM '10, F '21, Member for Life), chief engineer, American Telephone and Telegraph Company, New York, N. Y., has been named Director of the Public Works Department of Montclair, N. J. Past president of the AIEE (1942–43), he is Secretary of the Exploratory Group to Consider the Increased Unity of the Engineering Profession, which was formed by the invitation of the Engineers Joint Council. He is a very active member of the Institute having served as Director (1938–42). Some of the AIEE committees he has served on include: Finance, Planning and Co-ordination, Standards, Communication, Technical Program, Education, Publication, Edison Medal, and many others.

**B. R. Teare, Jr.** (AM '29, F '42), Head, Electrical Engineering Department, Carnegie Institute of Technology, Pittsburgh, Pa., has been appointed associate dean of the Carnegie Institute of Technology College of Engineering and Science. Dr. Teare is also Dean of Graduate Studies. He joined the Carnegie faculty in 1939 and was named Buhl Professor in 1943. As such, he was responsible for the establishment and organization of a graduate program in the Electrical Engineering Department. He is nationally known for his work in engineering education. Dr. Teare is a member of the Institute of Radio Engineers, the American Society for Engineering Education, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. An active member of the AIEE, he has served on the following committees: Communications (1934–36); Electric Machinery (1937–42); Education (1941–52, Chairman 1948–50); Technical Program (1948–50); Publication (1948–50); and is currently serving on the Edison Medal committee.

**R. H. Krieble** (AM '48), assistant engineer and head, chemical section, Thomson Laboratory, General Electric Company, Lynn, Mass., has been appointed engineer in charge of the laboratory. He has been associated with General Electric since 1943 when he joined the company's Research Laboratory. In 1946, Dr. Krieble was sent by the company, in co-operation with the United States Department of Commerce, to Germany to investigate methods of manufacturing plastics intermediates. Following this assignment, he investigated laboratory developments in chemistry at General Electric's affiliated electrical manufacturing companies in Europe. He is a member of Sigma Xi, the American Chemical Society, and the American Association for the Advancement of Science.

**J. E. Dean** (M '41), professor of electrical engineering, Texas College of Arts and Industries, Kingsville, Tex., has been appointed professor of electrical engineering and Head of the Electrical Engineering Department, Colorado State College of Agriculture and Mechanic Arts, Fort Collins, Colo. He was graduated from Michigan State College with a bachelor of science degree in electrical engineering in 1930, and he received his master of science degree in electrical engineering from Iowa State College, Ames, where he taught for 5 years. He also taught at the University of Vermont, Burlington, for 1 year before becoming associated with Texas College of Arts and Industries in 1948.

**A. G. Schifino** (AM '40), manager, sound equipment division, Stromberg-Carlson Company, Rochester, N. Y., has been elected general manager of the sound equipment division. Mr. Schifino was associated with Stromberg-Carlson from 1929–31 and he rejoined the company in 1940 as engineer in charge of the sound equipment laboratories; 2 years later he was placed in charge of the sound equipment division of the company. Mr. Schifino is a member of the Institute of Radio Engineers.

**F. P. Taugher** (AM '35, M '44), manager, Industrial Control Engineering Department, Westinghouse Electric Corporation, Buffalo, N. Y., has been appointed to the position of assistant to the vice-president. Mr. Taugher joined Westinghouse in 1927, and after serving in various engineering capacities in 1943, he became manager of the Boston (Mass.) Engineering and Service Department. He was appointed to his industrial control position in 1949.

**David Sarnoff** (M '23, F '51), Chairman of the Board, Radio Corporation of America, New York, N. Y., has been elected as the first recipient of the Radio-Television Manufacturers Association Annual Award for outstanding contributions to the advancement of the radio-television industry. General Sarnoff served the AIEE on the Edison Medal Committee (1943–48).

**P. F. Williams** (AM '07, Member for Life), President, and **A. E. Papp** (M '49), general manager, both of the G & W Electric Specialty Company, Chicago, Ill., have been elected Chairman of the Board and Executive Vice-President respectively. Mr Williams has served with the company continuously since 1928. He was elected President in 1950. Mr. Papp joined the company in 1929. He was appointed general manager in 1950.

**K. C. DeWalt** (M '46), manager, cathode-ray tube division, General Electric Company, Syracuse, N. Y., has been named manager of engineering, Tube Department, General Electric Company, Schenectady, N. Y. Mr. DeWalt was graduated from the University of Iowa in 1927 and joined the company the same year. After holding various positions, he was made manager of the cathode-ray tube division in 1949.

**H. A. Ploch** (AM '49), William Orrison Engineers and Associates, San Antonio, Tex., has been appointed sales application engineer, Southwestern District Sales Office, Reliance Electric and Engineering Company, Houston, Tex. Mr. Ploch was graduated from Texas Agricultural and Mechanical College with a bachelor of science degree in electrical engineering in 1944. He is a member of the Society for Advancement of Management, Texas Society of Professional Engineers, and the National Society of Professional Engineers.

**R. J. Kochenburger** (AM '49), assistant professor of electrical engineering, University of Connecticut, Storrs, has been promoted to full professorship. Dr. Kochenburger was the 1950 Alfred Noble Prize winner. At present he is directing a research project on a specialized analogue computer for the United States Air Force at the University. He is a member of Sigma Xi and Eta Kappa Nu. He is currently serving the AIEE on the Feedback Control Systems Committee.

**E. C. Brown** (AM '26, M '43), assistant to the president, Hartford (Conn.) Electric Light Company, has been granted a leave of absence to be power consultant for the Defense Electric Power Administration of the United States Department of Interior. His new duties will be in connection with the present emergency problems of expansion of power capacities of the nation's electrical utilities.

**Alan Howard** (AM '28, M '35), general manager, Gas Turbine Department, General Electric Company, Schenectady, N. Y., has been appointed manager of the gas turbine division's engineering department. Mr. Howard became associated with the company in 1927 after graduating from Purdue University with a bachelor of science degree in electrical engineering. He served on the AIEE Education Committee (1934–36).

**H. W. Poole** (M '50), manager, steel mill division, General Electric Company, Schenectady, N. Y., has been named manager of engineering in the company's newly formed Industry Control Department. Mr. Poole joined the company in 1934 after graduating from Kansas State College with a bachelor of science degree in electrical engineering.

**H. K. Weiss** (M '50), supervisory ballistician, Ballistic Research Laboratories, Aberdeen Proving Ground, Md., has been appointed chief of the Ordnance Engineering Laboratory. He is a member of the Institute of Aeronautical Engineers, and he has served the AIEE on the Feedback Control Systems (1949–50).

**J. C. Forbes** (M '49), supervisory engineer, Lamp Department, General Electric Company, New York, N. Y., has been named manager of the company's Lighting Institute at Nela Park, Cleveland, Ohio. Mr. Forbes joined the company in 1937 and is an authority on industrial lighting. He is a member of the Illuminating Engineering Society.

**W. W. Bender** (M '50), chief, Electro-Mechanical Department, Glenn L. Martin Company, Baltimore, Md., has been appointed chief electronics engineer. He has been associated with the company since 1939. He served the Institute on the Feedback Control Systems Committee (1949–51).

**L. E. Ackmann** (AM '49), sales engineer, Allis-Chalmers Manufacturing Company, Chicago, Ill., has been named manager of the Peoria (Ill.), branch of the general machinery division of the company. Mr. Ackmann was a sales engineer for Allis-Chalmers in the Chicago district for 4 years.

**A. E. Fitzgerald** (AM '31, M '39), and **J. G. Trump** (AM '31, M '48), both associate professors, Massachusetts Institute of Technology, Cambridge, have been promoted to the rank of full professor. Mr. Trump is currently serving on the AIEE Nucleonics Committee.

**E. J. Angelo, Jr.** (AM '42), and **R. J. Cypser** (AM '48), both instructors in electrical engineering, Massachusetts Institute of Technology, Cambridge, have been made assistant professors.

**H. E. McWethy** (M '25), engineer, Research Department, Twin City Rapid Transit Company, Minneapolis, Minn., has been named executive secretary of the Minnesota Society of Professional Engineers. He is a past president of the society.

# OBITUARY . . .

**William H. Reed** (AM '26, M '43), new development and consulting engineer, Bruce Electric Company, New York, N. Y., died on May 7, 1952. He was born on March 13, 1880, in Norwalk, Conn. From 1898 to 1918 he was engaged in design construction and operation of central power plants and industrial power and lighting installations throughout the Eastern United States. He was associated with Todd Shipyards Corporation, Hoboken, N. J., as an electrical engineer from 1918 to 1945. Mr. Reed was a member of the Society of Naval Architects and Marine Engineers. He served on the following AIEE committees: Marine Transportation (1926–52, Chairman 1945–48); Technical Program (1945–48); Standards (1945–48); and General Applications Co-ordinating, General Applications Division (1947–48, 1950–52).

**Francis Schaar Benson** (AM '28, M '36, F '50), assistant engineer, Engineering Department, Pacific Gas and Electric Company, San Francisco, Calif., died on April 18, 1952. He was born on July 5, 1895, in Beardstown, Ill., and attended the University of California. He began his career with the Pacific Gas and Electric Company in 1919 as an electrical draftsman. Mr. Benson was the author of several technical articles on electric distribution and substation design. He was a member of the Institute of Radio Engineers and the American Association for the Advancement of Science. He was Chairman of the San Francisco Section of the AIEE and served the Institute on the Sections (1949–51) and Switchgear (1949–51) Committees.

# MEMBERSHIP . . .

## Recommended for Transfer

The Board of Examiners at its meeting of May 15, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

### To Grade of Member

Adkins, B. G., supt., electric dept., Water, Gas & Electric Depts., City of Danville, Va.
Bay, F. H., staff engr., The Pacific Tel. & Tel. Co., Portland, Oreg.
Borror, C. M., engineer, Chesapeake & Potomac Telephone Co., Washington, D. C.
Brem, H. C., application engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Briggs, W. A., vice-pres., Marquette Electric Switchboard Co., Chicago, Ill.
Brown, H. A., asst. supt., Rochester Gas & Electric Corp., Rochester, N. Y.
Cann, H. M., application engr., Crocker-Wheeler div., Elliott Co., Ampere, N. J.
Cozzarin, V. J., plant mgr., Westinghouse Electric Corp., Cleveland, Ohio
DelCol, A., foreman, Westinghouse Electric Corp., Cleveland, Ohio
Dickinson, H. C., asst. to manager of engg., General Electric Co., Lynn, Mass.
Essel, C. J., elec. engg. associate, Department of Water & Power, Los Angeles, Calif.
Fennell, F. C., elec. engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Ferris, R. T., field engr., Philadelphia Electric Co., Philadelphia, Pa.
Fisher, R. M., Jr., design engr., General Electric Co., Lynn, Mass.
Gantt, J. S., section engr., meter & instrument lab., General Electric Co., West Lynn, Mass.
Gareau, L. E. A., supt., Rapide Blanc & Trenche Developments, Shawinigan Water & Power Co., Rapide Blanc, Que., Can.
Giannetto, C., senior engr., The Bechtel Corp., Los Angeles, Calif.
Gleason, G. F., technical engr., Rochester Gas & Electric Corp., Rochester, N. Y.
Gomberg, H. J., asst. prof., University of Michigan, Ann Arbor, Mich.
Grenfell, K. P., application engr., General Electric Co., Schenectady, N. Y.
Halfhill, D. W., design engr., General Electric Co., Lynn, Mass.
Holzer, O. E., engr., General Electric Co., Columbus, Ohio
Hunt, R. A., senior engr., Cleveland Electric Illuminating Co., Cleveland, Ohio
Joyal, H. J., designing engr., General Electric Co., Pittsfield, Mass.
Kelley, J. B., elec. engr., Burns & Roe, Inc., New York, N. Y.
Kruesi, W. R., design engr., General Electric Co., Lynn, Mass.
Larson, C. A., distribution supt., St. Joseph Light & Power Co., St. Joseph, Mo.
Massie, C. C., elec. operating engr., Union Electric Co., St. Louis, Mo.
Mayo, G. E., elec. engr., Consolidated Machine Tool Corp., Rochester, N. Y.
Murchie, S., mgr., Hydro Electric Commission, Brantford Township, Ont., Can.
Myers, F. W. A., engg. development engr., Philadelphia Electric Co., Philadelphia, Pa.
Myers, J. D., engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Newman, R. C., service engr., General Electric Co., Pittsfield, Mass.
O'Neal, M. B., consulting & application engr., Westinghouse Electric Corp., Memphis, Tenn.
Priebe, H. W., senior planning engr., The Detroit Edison Co., Mt. Clemens, Mich.
Reilly, J. E., consulting & application engr., Westinghouse Electric Corp., Pittsburgh, Pa.
Renne, H. S., technical editor, *Radio & Television News*, New York, N. Y.
Richardson, E. J., operating engr., General Waterworks Corp., Pine Bluff, Ark.
Robisch, I. C., elec. engr., Ebasco Services Inc., New York, N. Y.
Roblee, J. E., consulting & application engr., Westinghouse Electric Corp., Pittsburgh, Pa.
Russell, L. T., elec. engr., Commonwealth Associates, Inc., Jackson, Mich.
Shands, G. K., general foreman, Virginian Railway Co., Narrows, Va.
Shultz, E. A., chief system supervisor, Illinois Power Co., Decatur, Ill.
Shumaker, L. L., electrical engr., Delco Products Div., GMC, Dayton, Ohio
Slezak, S. T., engr., New York Telephone Co., New York, N. Y.
Stuart, E. F., service engr., Interstate Electric Co., Fort Smith, Ark.
Taylor, G. Y., asst. div. supt., Public Service Co. of Northern Illinois, Evanston, Ill.
Tikare, T. B., asst. engr., British Insulated Callender's Cables, Ltd., Bombay, India
Umnitz, M. B., engr., Illinois Bell Telephone Co., Chicago, Ill.
Verzuh, F. M., instructor, Massachusetts Institute Technology, Cambridge, Mass.
Ward, A. J., asst. sales engr., S & C Electric Co., Chicago, Ill.
Wasmund, J. A., Westinghouse Electric Corp., East Pittsburgh, Pa.
Whelan, F. G., research elec. engr., Corning Glass Works, Corning, N. Y.
Whitaker, E. R., electrical supt., Union Electric Co. of Missouri, St. Louis, Mo.
Williams, G. O., design engr., Hobart Brothers Co., Troy, Ohio
Williams, J. W. A., power plant supt., Bowater's Newfoundland Pulp & Paper Mills, Ltd., Newfoundland, Can.
Williams, R. B., sales engr., General Electric Co., Philadelphia, Pa.
Wilson, R. S., elec. engr., California Packing Corp., San Francisco, Calif.
Wollgast, L. A., engr., Detroit Edison Co., Detroit, Mich.
Yasi, J. W., engineer, General Electric Co., West Lynn, Mass.
Yetter, J. W., application engr., General Electric Co., Schenectady, N. Y.
Zimmermann, S. A., section engr., General Electric Co., Fort Wayne, Ind.

62 to grade of Member

## Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, havy been received from the following candidates, and and member objecting to election should supply a signer statement to the Secretary before July 25, 1952, on September 25, 1952, if the applicant resides outside of the United States, Canada, or Mexico.

### To Grade of Member

de Poutiloff, J., Le Materiel Electrique S. W. of France, c/o Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Flurscheim, C. H., Metropolitan Vickers Elec. Co. Ltd., Manchester, England
Hobson, A., Smith Hobson Ltd., Kingston-on-Thames, Surrey, England

3 to grade of Member

# OF CURRENT INTEREST

## Pictorial Computer Indicates Plane's Position Utilizing OBD Principles

Operational safety on the airways has been improved by the development of an instrument which automatically calculates an aircraft's distance and azimuth from a known point of radio transmission on the ground. The instrument is called a pictorial computer and was designed, developed, and manufactured by Arma Corporation, subsidiary of American Bosch Corporation, Brooklyn, N. Y.

Smaller than radio equipment of earlier vintages, the pictorial computer mounts flush on the airplane instrument panel. There, within detail-seeing range of both pilot and copilot, it continuously displays on a luminous screen the exact orientation of the aircraft with respect to the ground. Accuracies claimed are: range ±0.4 mile at all scales, bearing ±1/2 degree or ±1/32 inch, and heading indicator ±1 degree.

Navigation with the pictorial computer is based on the Omni-Bearing Distance (OBD) System and is simply a matter of selecting the proper chart and keeping the aircraft heading, corrected for crab angle, in line with the route or destination. For example, in an airplane leaving LaGuardia Airport, New York, N. Y., for the West, the pilot would select either the route or sectional scale chart of the Caldwell OBD station. As the aircraft flies west, the computer will indicate position and heading, continuously tracking the aircraft, and the pilot may control the airplane to remain in the assigned airway. As the flight position moves off the chart, the pilot will operate the slewing control to select the desired chart of the next OBD station at Allentown, Pa. Ordinarily the next chart required will be adjacent to the chart last used on the film strip, so that chart-changing time is minimum. Laboratory tests indicate that time for selection of new charts in this way will not exceed 10 seconds. This procedure is repeated at intervals of 15 to 30 minutes (depending on aircraft speed and chart scale).

A flag alarm is provided to indicate failure in the pictorial computer, in the inputs to the computer, or to indicate when the range to the OBD station is so great that signals received at the aircraft are below the usable threshold strength.

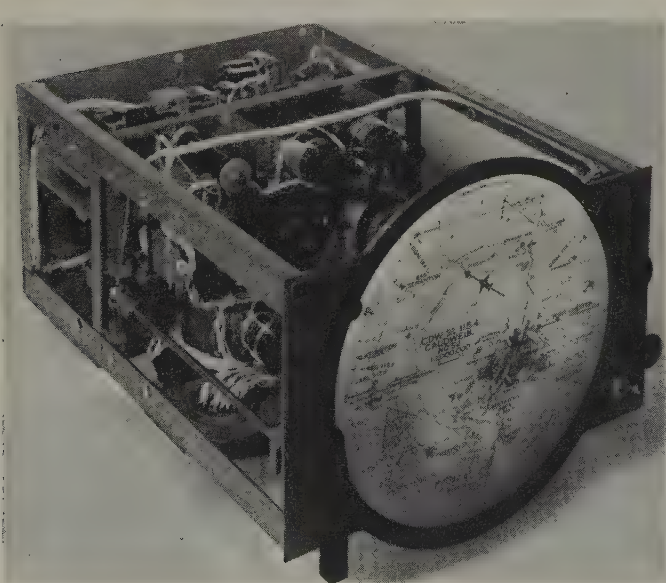
The pictorial computer with heading, automatic chart selection, and automatic receiver tuning, is designed to display visually and continuously aircraft heading and position over the ground with respect to a preselected known point. The display unit is designed to be mounted in the instrument panel of an aircraft, and to be clearly visible to both pilot and copilot under all operating conditions. The charts against which position and heading are shown in the display unit are self-contained, and are quickly selectable by means of a slewing control on the front of the unit. The equipment is composed of two principal units: the display unit; and the amplifier unit, containing all relays, special power sources, and amplifiers. The amplifier unit is intended to be mounted in the radio rack of an aircraft and is of a standard outline size.

Aircraft heading and position are shown against a chart of the area. The chart is part of a 35-millimeter film roll in the display unit, and is projected at 10 times magnification onto a 10-inch diameter, see-through-type screen. At the center of the chart is an OBD station, which is the fixed geographical point from which the pictorial computer and associated equipment calculate range and bearing for position indication. Aircraft position is indicated on the chart as the center of a reticle of concentric range circles and radiating bearing lines. Aircraft heading is indicated on the chart by a series of arrows passing through the aircraft position and, in addition, by a symbolic aircraft outline. Heading may be read to 1 degree against compass roses superimposed on several range circles. Any point on the chart may be headed for simply by turning the aircraft until the heading indicator points toward and falls over the chosen spot. Then except for the crab angle necessary to compensate for wind set and drift, the aircraft will, in due course, pass over the required point. Setting up the crab angle is easy to do, since it is necessary only to swing the aircraft into the wind in increments until the required point on the chart is held at a constant bearing. Bearing lines are spaced conveniently so that small changes in bearing may be detected quickly.

Charts are provided at four scales: 1:2,000,000 (direction finding charts); 1:1,000,000 (route charts); 1:500,000 (sectional charts); and 1:250,000 (local charts). Chart diameters are 274, 137, 64, and 34 miles, respectively.

Storage facilities in the display unit allow for a film roll containing up to 700 charts. The total number of OBD stations presently authorized is 291, so that the designed chart capacity allows for charts at various scales, as required, including some to be used for small-scale airport approach charts.

Charts are situated on the film in a route sequence order. The route sequence is made up of a series of film strips, each strip containing the charts for OBD stations




**Chassis of pictorial computer display unit (shown at left) has a 10-inch image of chart projected through a Fresnel lens and prism grating to obtain even 60-degree viewing by pilot and copilot. A chart selector (shown at right), with a variable-speed motor-driven device, drives the chart's film roll up to a maximum slewing speed of ten charts per second**

## Future Meetings of Other Societies

**American Chemical Society.** Seventh National Chemical Exposition. September 9–13, 1952, Chicago Coliseum, Chicago, Ill.

**American Society for Testing Materials.** Annual Meeting. June 23–27, 1952, Hotel Statler, New York, N. Y.

**American Standards Association.** Third National Standardization Conference. September 8–10, 1952, Museum of Science and Industry, Chicago, Ill.

**Illuminating Engineering Society.** National Technical Conference. September 8–13, 1952, Edgewater Beach Hotel, Chicago, Ill.

**Instrument Society of America.** National Instrument Conference and Exhibit. September 8–12, 1952, Cleveland, Ohio.

**Photographic Society of America.** Technical Division. August 12–16, 1952, Hotel New Yorker, New York, N. Y.

**The American Society of Mechanical Engineers.** Fall Meeting. September 8–11, 1952, Sheraton Hotel, Chicago, Ill.

encountered in a route between two terminal cities. The chart for any given station may be located by reference to an index sheet which provides the number of the film strip in which the particular station is located and by use of the call letters of the station at the chart center. The arrangement of charts is such as to minimize the amount of film movement required, particularly during flight.

A chart selector motor, in conjunction with a variable-speed device, drives the film roll at any desired speed up to a maximum slewing speed of ten charts per second. The film may be readily driven at a speed slow enough to enable the OBD station call letters to be read directly from the chart image.

Associated with each chart in the film roll there is a series of 11 on-off coded locations. Nine of these locations are used to identify the particular frequency combination of the OBD station transmitters and transponders situated at the center of each chart. Two are used to set the scale of the instrumentation automatically to correspond with the scale of the chart. The coded locations consist either of holes or no holes in the film roll. Fingers interrogate each coded location as soon as the chart has been selected. The fingers actuate a relay network in the amplifier unit, which in turn controls automatically and remotely the autopositioner tuning mechanisms in both the navigation receiver (bearing) and distance measuring equipment (range), so that, after a particular chart has been selected at the display unit, inputs to the pictorial computer are retuned automatically to the new OBD station.

Instrumentation of the pictorial computer is accomplished with three servos: range, bearing, and heading. All are of conventional design and operate on 400-cycle signal inputs. Range is obtained from the shaft orientation of a potentiometer in the distance measuring equipment, which calculates the distance, up to 115 miles, to the OBD stations to which it is tuned. Bearing is obtained as a single-speed 400-cycle synchro signal from the omni-bearing indicator, a unit of the navigation receiver which calculates bearing to the OBD station to which the receiver is tuned. Magnetic heading is received as a 400-cycle single-speed synchro signal from the gyrosyn compass.

The pictorial computer is completely automatic except for the selection of charts, and for certain initial adjustments. After power is turned on at the power switch, the desired chart is selected by first pulling out on the slewing handle to actuate the chart-changing mechanism. The handle is then turned to right or left, depending on whether the chart desired is part of a film strip with a number greater or less than the chart being viewed. The greater the amount of turn, the greater the slewing speed. The slewing may be stopped completely, even though powered, by holding the handle near dead center. Release of the handle, regardless of position, will cause it to center automatically and de-energize the chart selector motor. Provision is made within the chart-changing mechanism to center automatically the chart selected. This does away with "hunting" in an attempt to center the desired chart accurately.

When the correct chart is in the projector system, the image brightness may be adjusted by a knob. This permits operation under widely varying conditions, from sunlight to darkness. Projector lamps to be used in the pictorial computer are expected to have a minimum life of 100 operating hours, with average life at least 150 hours. A spare lamp is provided for in the display unit and, when the lamp in use burns out, the spare may be brought into position in the optical system at once by pulling a flexible cable brought out to the front of the unit. The flexible cable handle is left out (a length of about 2 inches) as a reminder to replace lamps at the next ground facility.

The display unit is about 13 by $7^1/_2$ by $17^1/_2$ inches, except for blisters at the front (screen end) to accommodate the 10-inch round screen, and another blister at rear to accommodate the lamp house of the projector system and its blower. It is mounted to the instrument panel in the cockpit of an aircraft, and weighs about 16 pounds. Dimensions and weight do not include shockmounts.

Special new charts will be furnished for use with the pictorial computer. They will be prepared by the United States Coast and Geodetic Survey in co-operation with the Civil Aeronautics Administration, and will be designed for use by high-speed aircraft and for all types of flying where visual ground contact is not maintained. Chart legends will be clearly visible from a distance of 40 inches, about the distance of the instrument panel from the pilot's eyes. Charts will be prepared in solid black and halftones, and will contrast with the position and heading indicators of the computer.

# Problem-Solving Electric Mouse Aids in Improved Telephone Equipment Research

An electric mouse with a man-made super-memory is busily at work these days, repeatedly threading its way through a series of complicated mazes at Bell Telephone Laboratories. The handiwork of Dr. C. E. Shannon, a mathematician associated with the Bell Telephone Laboratories, Inc., the mouse uses for its "brain" some of the same kind of switching relays found in dial telephone systems. The reason it exists is to provide fundamental knowledge which will help improve telephone service.

The mouse, in reality a 2-inch bar magnet with three wheels and copper whiskers, can solve quickly more than a million million different mazes, learning each new one rapidly, then instantly forgetting it in order to be ready to learn the next one. Its goal is an electric terminal with a bell which rings when the mouse nudges it with its copper whiskers.

The maze is about half the size of a desk top. It has aluminum fences which can be rearranged at will in 40 different slots to create the hardest possible problems for the mouse. The mouse is placed at some arbitrary point in the maze and the goal at a different arbitrary point. After a brief pause to get its bearings, the mouse goes up and down corridors, bumping into walls, backing up and turning, and exploring until, a minute or two later, it reaches its goal and rings the bell.

Having learned the correct path to the goal, the mouse now can be set down at any point that it visited during its explorations and, without making a single false move, it will proceed directly to the goal in 12 to 15 seconds. If it is placed in a part of the maze not previously visited, it will explore until it reaches a known part and then move directly to the goal.

After this, if the maze is altered, the mouse will have to learn the new paths by further exploration, but it readily will remember those parts of the path which remain unchanged.

This is the way the mouse works. When it is set down on the metal floor of the maze, it trips an electric switch which signals its position to a mechanism under the floor. A motor-driven electromagnet moves swiftly to the spot directly beneath the mouse and from then on holds it in a magnetic grasp. The magnet turns through a 90-degree angle, carrying the mouse with it, then guiding it forward. If the mouse hits a barrier and detects, by means of its copper whiskers, that it is in a dead end, the magnet will back away, shift the mouse to another direction, and start it forward to try again to find an open path. It keeps trying until it finds the way to the goal. Then it remembers the successful path and can solve the maze directly without error.

To regulate the sequence of movement, a "programming" circuit has been built, consisting of 40 electric relays. Another part of the mouse's "brain," which serves as its memory, contains 50 relays. Two small motors complete the equipment.

By working with such problem-solving equipment, it is hoped that more will be learned about what man can do with machines. Many of the techniques by which machines are able to remember are cur-

**The Bell Telephone Laboratories' electric mouse is shown at right being set down in a maze through which it will find its way to a goal which is really an electric terminal. Time exposures (above) show the path taken by the mouse. The pattern on the left, made by attaching a small light to the back of the mouse, shows the mouse's explorations on its 2-minute trip to the goal in the lower right-hand corner. Illustration on the right shows what the mouse can do once it has made this exploration**

rently being applied in the Bell System in dial switching, in automatic accounting, and in other equipment.

The real significance of this mouse and maze, lies in the four unusual operations it is able to perform. It has the ability to solve a problem by trial and error means, remember a solution and apply it when necessary at a later date, add new information to the solution already remembered, and forget one solution and learn a new one when the problem is changed.

## UPADI to Hold Meeting in New Orleans, La., August 25-30

The second convention of UPADI (Pan-American Union of Engineering Societies) will be held in New Orleans, La., August 25–30, 1952. It is expected that the meeting will attract approximately 200 engineers representing the professional societies throughout Central and South America. The site and time were chosen to permit the Latin delegates to participate in the observances commemorating the Centennial of Engineering being held in Chicago, Ill.

UPADI was formed to provide a common meeting ground for Western Hemisphere engineers, a means to discuss mutual problems and an opportunity to exchange ideas and information. The AIEE takes part in its activities through Engineers Joint Council (EJC).

**Campus of Tulane University, New Orleans, La., where the UPADI Meeting, August 25–30, will be held**

The first UPADI Congress was held in Rio de Janeiro, Brazil, July 1949. Many Latin societies attended, and EJC sent official observers. At the meeting several papers were presented and a provisional Constitution drawn up. This document was negotiated and revised during the period following the Congress. At a convention in Havana, Cuba, April 1951, UPADI was constituted formally. Shortly thereafter EJC signified its adherence to the organization.

The second convention in New Orleans will consider further revisions in the Constitution and adopt a set of bylaws. A technical program will be held on August 26th. Its theme will be "Engineering Education." The program is being developed by L. J. Lassalle, Dean, College of Engineering, Louisiana State University. Two papers prepared by Latin delegates will be presented during the morning session. In the afternoon papers on the situation in the United States and Canada will be delivered.

While a good part of the convention will be devoted to organization and business, arrangements have been made to inspect the facilities of the Port of New Orleans and visit plants in the vicinity. Various social affairs are scheduled including a formal banquet on August 29th. A program for the ladies also is being planned.

The convention will meet at Tulane University where living quarters have been provided for the delegates. McAlister Auditorium will be the center of the convention activities. Spanish-English interpreters will be on hand to take care of the convention proceedings. A special UPADI committee has set up various subcommittees to handle details of the convention. Each local section of the Founder Societies has a member on these committees.

The President of UPADI is Luis Gian-

nattazio of Montevideo, Uruguay. He will serve through 1954. J. M. Todd, Chairman of the special UPADI committee and in charge of arrangements for the New Orleans meeting, is Vice-President. Manuel J. Puente of Havana, Cuba, is Treasurer. Representatives of societies in Argentina, Brazil, Canada, Colombia, El Salvador, and Honduras make up the Board of Directors.

**Program for UPADI Convention, New Orleans, La., August 25–30, 1952**

**Monday, August 25**

Morning.......Registration
Afternoon......Plenary Session
Summary of developments since Havana
Conferences by committees to complete their reports
Evening........Meeting of Board of Directors

**Tuesday, August 26**

Morning.......Papers on "Engineering Education" by Latin delegates
Luncheon......Speaker on "Engineering Education"
Afternoon......Program similar to morning session with United States and Canadian papers
Evening........Informal exchange of greetings by representatives of various delegations

**Wednesday, August 27**

Morning.......Plenary Session to receive and act on reports
Afternoon......Continuation of morning session
Evening........Special entertainment for delegates

**Thursday, August 28**

Morning and
Afternoon....Port trip and other excursions

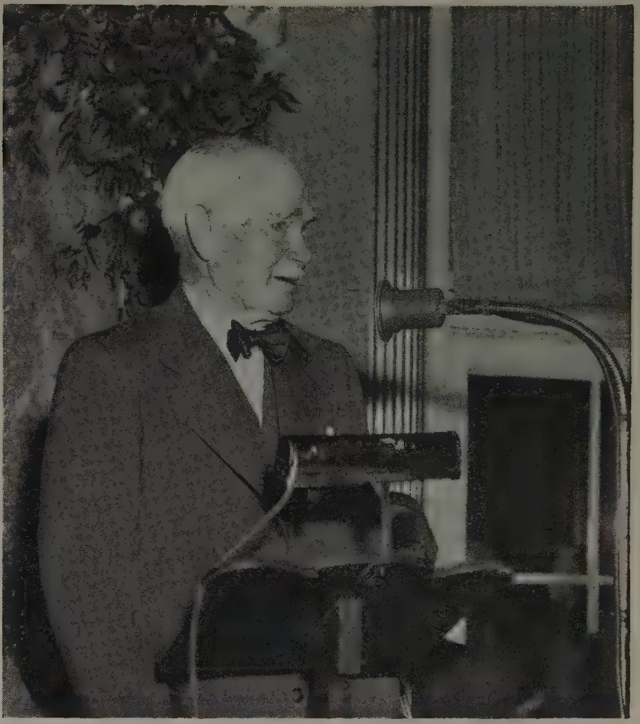
**Friday, August 29**

Morning.......Plenary Session
Final action on committee reports
Resolutions
New appointments
Afternoon......Panel discussion on engineering aspects of industrial developments and financing in Latin America
Evening........Formal Banquet

**Saturday, August 30**

Morning.......Concluding business and ceremonies

# De Forest Honored for Radio Achievements



**Dr. Lee de Forest, shown speaking at a luncheon given by Sylvania Electric Products, Inc., to honor 30 pioneer broadcasting personalities. Dr. De Forest, called "Father of Radio," was one of 30 persons to receive Sylvania's Billionth Tube Pioneer Award presentations for achievements in the field of radiobroadcasting**

## Research Nuclear Reactor in Operation Under Water

Development of a relatively inexpensive, low-power nuclear reactor, unique in that it is submerged in water to protect operators from radiation, was announced recently by the Oak Ridge (Tenn.) Operations Office of the United States Atomic Energy Commission (AEC).

The reactor was pioneered and developed by scientists at Oak Ridge National Laboratory, which is operated for AEC by the Carbide and Carbon Chemicals Company, a division of the Union Carbide and Carbon Corporation.

The reactor is the central feature of a bulk shield testing facility which is used for experiments to aid development of improved reactor shields. The facility is popularly known as the swimming pool, since the reactor is submerged in a pool of water 20 feet deep, 20 feet wide, and 40 feet long, in which it can be moved about. The reactor became critical on December 17, 1950, and was placed in operation soon afterward.

This swimming pool reactor has a continuous, full-load power rating of 10 kw, at which it produces a maximum flux, or neutron density, of approximately 100 billion thermal neutrons per square centimeter per second.

This reactor has proved to be an economical and safe producer of radiation for certain purposes. For these reasons, as well as low cost, simplicity, and performance, it is one of several types of reactors which might be suitable for use at schools and other research and training institutions. The purposes best served by each type differ and the estimated costs vary considerably.

The reactor is an assembly of movable fuel elements placed on end in an aluminum grid. It is suspended by an aluminum framework from what is called the reactor bridge, which spans the pool. The bridge rests on wheels fitted to rails along either side of the pool, so that the reactor can be moved along a center line the length of the pool.

Similarly, an instrument bridge spans the pool and operates on the rails. A steel framework attached to the movable mechanism of this bridge extends nearly to the bottom of the pool. Using a carriage that slides up and down on the framework, operators can place test instruments at any point in the pool.

A useful feature of the facility is an aluminum gate, 12 feet high and 21 feet long, 10 feet from the south end of the 130,000-gallon pool. When the reactor is moved to this end of the pool, the gate can be lowered and the greater area of the pool can be blocked off and pumped dry. Thus, some repairs and adjustments are facilitated, and instruments and shielding samples can be placed easily in desired spots, with personnel meanwhile protected from radiation.

Shielding measurements on samples can be made also in the open air, with samples placed near the dry side of the gate and the reactor moved close to the other side of the gate.

Centered on the bottom surface of the pool is a well, 14 feet square and 5 feet deep. This well is filled with removable blocks of high-density concrete, giving part of the pool an adjustable floor level for more flexibility in the placement of shielding samples and instruments.

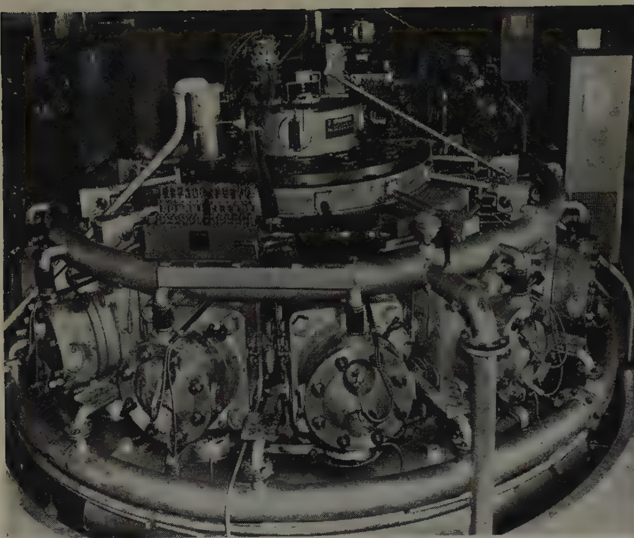
The reactor has a variety of potential uses in addition to its principal role as an aid in the testing of shields. It enables students and other investigators to perform critical experiments, study neutron distribution and, within limits, study the effects on reactor operation of various patterns of arrangement of the fuel elements.

Operated at full power, the reactor has a flux high enough to make long irradiation periods unnecessary for most experiments. With the neutrons available from this reactor, scientists can study phenomena of short-life beta and gamma radiation.

The swimming pool helps also in the expanding practice of chemical analysis by making specimen materials radioactive. In addition, since a neutron beam from this reactor can be collimated, that is, in a sense, "focused" with ease, equipment for neutron diffraction research can be used with this facility.

## ALCOA Increases Gas-Fueled Power Generating Facilities

A 70-per-cent increase in aluminum smelting capacity has been made possible at Aluminum Company of America's (ALCOA) Point Comfort (Tex.) Works by an addition to its gas-fueled power-



One of 74 12-cylinder radial engines installed in two new powerhouses at the Aluminum Company of America's Point Comfort (Tex.) Works. The engines use natural gas for fuel

generating facilities. Point Comfort, the world's largest internal combustion engine generating station, now has a total engine rating of approximately 350,000 horsepower.

The increase in available power will give Point Comfort an aluminum-producing capacity of 85,000 tons annually.

The original power plant included 120 engine-generator units, 40 of them housed in each of three buildings. To increase the power output, 74 new units have been installed in two additional buildings.

All 194 engines, built by Nordberg Manufacturing Company, are of the 2-cycle, radial type, incorporating an advanced design of dual spark ignition. The engines have a 14-inch bore and a 16-inch stroke.

Although the 74 new engines are similar in general design and appearance to the 120 original ones, there are important differences between the two. The new engines have 12 cylinders instead of 11 and, since the cylinders are the same size, the new model develops about 9 per cent more power.

In addition, a distinctly new type of stabilizing mechanism is employed in the new engine to permit the master crankpin bearing assembly to gyrate and yet to prevent it from rotating in response to the torque from the connecting rods. This was accomplished in the original 11-cylinder engine by means of a planetary gearing system.

In the new engines, however, a simple crank mechanism operating between two connecting rods and their knuckle pins is substituted for the gearing. The relatively small torque tending to rotate the master crankpin bearing assembly is absorbed by small reactions on two of the pistons.

Although the same impulse generator is used for ignition on both model engines, it is combined with the distributor as a single unit in the new model, instead of being driven separately.

Except for these changes, the two engines are essentially the same. In both models, intake and exhaust are timed by the pistons as they uncover ports in the cylinder walls. This eliminates intake and exhaust valves.

Natural gas is admitted by cage-mounted gas valves. The valves are operated by a cam on the crankshaft and are located so that the gas is admitted into the path of the incoming scavenging air. This assures thorough mixing and economical burning of fuel. A valve inserted in the gas line and controlled by a hydraulic governor varies the amount of gas delivered to the cylinders according to the load on the engine.

It has been found that the compact cylinder arrangement of the engine simplifies maintenance. All bearings are renewable bushings, and the heads, pistons, cylinders, and bearings are interchangeable. This reduces to a minimum the number of spares required.

Seventy-four electric generators are located in the lower level of the new powerhouses and are joined to the engines by direct coupling. Each engine-generator unit, with its auxiliaries, operates independently.

Each of the 74 generators produces 1,100 kw (d-c) at 667 volts, and 135 kva (a-c) at 425 volts and 24 cycles. The a-c power is used for driving auxiliaries such as the scavenging air blower, oil and water pumps, and radiator cooling and generator ventilating fans. This eliminates the need for a common auxiliary power system and the possibility of a total station interruption.

## Tau Beta Pi Honors A. C. Monteith

**On May 16, 1952, the Virginia Beta Chapter of the Tau Beta Pi Association initiated A. C. Monteith, (F '45), Vice-President, Westinghouse Electric Corporation, into membership. Following the ceremony, which was held at Virginia Polytechnic Institute (VPI), Blacksburg, Va., a banquet was held in honor of Mr. Monteith. Shown from left to right are: W. A. Murray (F '44), Head, Electrical Engineering Department, VPI; E. N. Norris, Dean of Engineering, VPI; A. C. Monteith; R. M. Jones, President, Virginia Beta Chapter; and R. H. Nagel, National Secretary-Treasurer, Tau Beta Pi, University of Tennessee, who presided at the ceremony**

## Benjamin F. Fairless Receives John Fritz Medal for 1953

Benjamin F. Fairless, President of United States Steel Corporation, was selected by the John Fritz Medal Board of Award to receive the 1953 John Fritz Medal and Certificate as "Champion of the American Free Enterprise System for Notable Industrial Achievement in the Production of Steel."

The John Fritz Medal was established in 1902 by friends of John Fritz on the occasion of his 80th birthday to honor him for his contributions in the manufacture of steel and in the advancement of industry generally. It is perpetuated by the four leading engineering professional societies; AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, and The American Society of Mechanical Engineers, as a joint honor for scientific or industrial achievement in any field of pure or applied science, without restriction on account of nationality or sex.

This award to Mr. Fairless is the culmination of a long series of honors which have been bestowed upon him for his achievement and leadership in the production of steel. Presentation of this award will be made at the Centennial Meeting of the American Society of Civil Engineers in Chicago, Ill., in September. Mr. Fairless is a member of the society.

Mr. Fairless was graduated with a degree in civil engineering in 1913 from Ohio Northern University. He acquired technical experience as civil engineer for the Wheeling and Lake Erie Railroad, then for the Central Steel Company where he advanced rapidly from civil engineering

through mill superintendent, general superintendent, and Vice-President in charge of operations, then President and General Manager of Central Alloy Steel. Through reorganizations, Mr. Fairless in 1930 became Vice-President of Republic Steel Corporation, and in 1935 President of Carnegie-Illinois Steel Corporation. In 1938 he was elected President of United States Steel Corporation.

## Stanford Institute New Source of Radioactivity for Research

The largest source of radioactivity outside of Atomic Energy Commission installations will be available for research in industrial uses of atomic and nuclear science when Stanford (Calif.) Research Institute opens its new Radiation Engineering Laboratory. The Institute has completed arrangements for obtaining a 5,000-curie source of Cobalt 60, a gamma-ray emitter, from Brookhaven National Laboratory, Upton, N. Y.

By curie measurement (the rate of atomic disintegrations per second), emissions from a 5,000-curie source are so powerfully penetrating that they could be partly duplicated only by about $100,000,000 worth of radium. Stanford's radioactive source will have five times the power of any presently available for industrial and medical research.

The new Radiation Engineering Laboratory is due to start operation in the very near future. It will develop and engineer practical safe systems for the use of large amounts of radiations in a wide variety of possible industrial applications.

Some of the promising uses to be investigated at any early date include nondestructive testing of metal castings and parts by radiography and the cold sterilization of heat-sensitive foods and drugs using penetrating gamma radiation.

Companies wishing to explore uses of radiation for their processes or products may bring samples to the laboratory for irradiation at a specified intensity and duration. The samples then may be returned to the company for analysis and study.

The institute will undertake experimental work using radioisotopes. Tracer techniques will be studied as a means of reducing the time and expense of complicated research problems.

Although the Cobalt 60 source has a high level of radioactivity it represents no safety hazard inasmuch as it will remain at all times in an underground water-filled tank. Protective devices, remote control equipment, and carefully controlled conditions for experimentation have been designed into the engineering system.

## In 1951 Research Corporation Granted $875,000 in Aid

Grants in aid totaling $875,000 were made by Research Corporation, New York, N. Y., in its 1951 fiscal year, it was announced recently. The sum was distributed in the form of 288 grants to educational and scientific institutions in 41 states, the District of Columbia, Hawaii, Canada, Formosa, India, Lebanon, and the Philippine Republic.

# NEW BOOKS . . . . .

**The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.**

ALL-PURPOSE DIESELS. By J. Malcolm Robson. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W. C. 2, England, 1951. 313 pages, illustrations, tables, diagrams, charts, 9¹/₄ by 6¹/₄ inches, bound. $10. A comprehensive technical survey of the design and practical applications of Diesel power units. Particular attention is given to the many practical uses of oil engines because such requirements have a material effect on engine layout and appearance. Several chapters deal with the development of oil engines and with the equipment for their starting, cooling, governing, and power transmission.

BIBLIOGRAPHIC SURVEY OF CORROSION. 1946–1947. By the Engineering and Publishing Staffs, National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Tex. (Publication Number 51–1) 1951. 288 pages, 11¹/₄ by 8³/₄ inches, bound. $9. A comprehensive bibliography compiled from the major abstracting services in the field as well as from a circle range of specialized indexing sources. The items are arranged according to a classification scheme devised by the NACE based on the careful subdivision of eight major sections: general, testing, corrosion types and influencing factors, corrosive environments, preventive measures, materials of construction, equipment, and industries. There are also an author index, a subject guide, and notes on how to secure copies of the articles indexed.

BLITZSCHUTZ. Edited by Ausschuss für Blitzableiterbau. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany, fifth edition, 1951. 79 + 18 pages, charts, diagrams, 8¹/₂ by 6 inches, bound. DM 6.50. Beginning with a review of the present knowledge of lightning and lightning danger, this small book continues with the "technical principles" to be followed in the construction of lightning-protection installations. Edited by a special German committee, the book contains official regulations and standards. Plates illustrate correct installations.

CENTRALI ELETTRICHE. By Mario Mainardis. Editore Ulrico Hoepli, Milan, Italy, second edition, 1952. 705 pages, diagrams, charts, illustrations, tables, 10 by 7 inches, paper. Lire 3,500. A comprehensive treatise on central stations covering both hydro- and steam power generation. In each case the general plant, the major machinery, and auxiliary equipment are dealt with in detail. Subsequent chapters treat the electric machinery, regulating and protective equipment, insulating materials and devices, dimensions, economics, and standards.

A COURSE IN ELECTRICAL ENGINEERING. By Chester L. Dawes. Volume I: Direct Currents. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., fourth edition, 1952. 736 pages, diagrams, tables, charts, illustrations, 9¹/₄ by 6¹/₂ inches, bound. $7. A standard textbook giving comprehensive coverage of fundamental electrical characteristics, primary and secondary batteries, electric instruments and measurements, magnetism, electrostatics, and d-c machinery. Numerous appendixes contain useful tables of technical data and sets of questions and problems for the various chapters.

ECHO SOUNDING AT SEA. (British Practice.) By H. Galway. Sir Isaac Pitman and Sons, Inc., London, England; available in United States from British Book Centre, Inc., 122 East 55th Street, New York 22, N. Y., 1951. 299 pages, tables, diagrams, charts, 8³/₄ by 6 inches, bound. $7.50. Beginning with a survey of the underlying principles of sound transmission, the book continues with a discussion of the technique of echo sounding at sea and the problems involved in the choice of a suitable site on the ship for the equipment. A detailed study of the design and operation of the main types of echo sounders is included. Fault finding and maintenance are covered with special ready-reference tables.

EINIGES UBER DIE GRUNDZUGE DER BLITZSCHUTZTECHNIK. By Volker Fritsch. Franz Deuticke, Helferstorferstrasse 4, Vienna, Austria, 1951. 100 pages, diagrams, charts, tables, illustrations, 9 by 6 inches, paper. $2.65. Not intended as a textbook on lightning protection for buildings, this publication presents prerequisites and technical details which must be taken into account in order to construct a correct and suitable installation. Special topics include the electrical properties of the soil, grounding details, materials, and various measurement methods.

ELECTRICAL MEASUREMENTS. By Forest K. Harris. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 784 pages, diagrams, tables, graphs, 9¹/₄ by 6¹/₄ inches, bound. $8. Comprehensive coverage is provided from basic principles to applications within the fields of d-c and low-frequency operation. The theory, construction, and functioning of all important instrument types are dealt with in broadly classified sections. In addition to providing a working knowledge of methods and apparatus, the author stresses the suitability, limitations, and necessary precautions in the use of special techniques. In an early chapter the origins, relations, and dimensions of electrical units are discussed.

ELECTRICAL PHENOMENA AT INTERFACES. In Chemistry, Physics and Biology. Edited by J. A. V. Butler. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y., 1951. 309 pages, tables, charts, diagrams, 8³/₄ by 5³/₄ inches, bound. $6.75. Based on a previous book by the author, the current work has been extended in scope by the addition of chapters by specialists in the basic researches on the subject. Topics covered include the following: electrical potential differences; the electrical double layer; electrokinetic effects and behavior; electrophoresis; stability of colloidal solutions; overpotential; behavior of gases at electrodes; the electrical properties of living cells, nerves, and muscle. Applications in colloid science, electrochemistry, biochemistry, and physiology are extensively discussed.

ELECTROLYTIC MANGANESE AND ITS ALLOYS. By Reginald S. Dean. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y., 1952. 257 pages, tables, charts, illustrations, 9¹/₄ by 6¹/₄ inches, bound. $12. This book is a record of the progress of the art of electrolytic manganese production and the development of its uses since 1936. The three major sections deal respectively with the following: production and properties of electrolytic manganese, including economic considerations; nonferrous alloys of electrolytic manganese; and ferrous alloys of electrolytic manganese. Special attention is paid to alloys in which the electrolytic type is necessary, and to alloys in which it produces properties significantly different from the use of other types of manganese.

EXTRUSION OF PLASTICS, RUBBER AND METALS. By Herbert R. Simonds, Archie J. Weith, and William Schack. Reinhold Publishing Corporation, 330 West 42d Street, New York 36, N. Y., 1952. 454 pages, tables, illustrations, diagrams, charts, 9 by 6¹/₄ inches, bound. $10. This book deals with extrusion as an important processing operation. Some three-fourths of the book is devoted to extrusion in the plastics industry, covering materials, equipment, methods, die design, instrumentation, and special problems in connection with the extrusion of shapes, tubes, sheets, films, and coatings. The remainder of the book covers the extrusion of metals, rubber, and miscellaneous materials, and provides a glossary and a brief buyers' guide.

THE FUNDAMENTALS OF TOP MANAGEMENT. By Ralph Currier Davis. Harper and Brothers, Publishers, 49 East 33d Street, New York 16, N. Y., 1951. 825 pages, charts, tables, 8¹/₂ by 5³/₄ inches, bound. $6. A handbook for executives and students of management, this comprehensive work on business organization presents objectives, policies, and general methods governing the solution of basic business problems. Among the problems of executive leadership and scientific management considered are line and staff organizations, organizational morale, control of operations, and business procedures. Detailed information is given on all aspects, and solutions are reviewed that have been successfully applied.

HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1952. Volume 30. American Society of Heating and Ventilating Engineers, 62 Worth Street, New York 13, N. Y., 1952. 1,496 pages, illustrations, tables, charts, diagrams, 9¹/₄ by 6¹/₂ inches, bound. $7.50. A standard reference book, its 50 chapters are devoted to such varied topics as the fundamentals of thermodynamics, the physiological bases of heating and air conditioning, the calculation of heating and cooling loads of enclosed spaces, and to descriptions of systems and apparatus such as steam-heating systems, panel heating, electric heating, refrigeration, and drying systems.

**Library Services**

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

PRAKTISCHE GETRIEBELEHRE. By Kurt Rauh. Volume I: Die Viergelenkkette. Springer Verlag, Reichpietschufer 20, Berlin W 35, Germany, second edition, 1951. 127,88 pages, illustrations, diagrams, charts, 10 by 6³/₄ inches, bound, D. M. 37.50. In this book mechanisms are discussed not from the point of view of the mathematician or student of theoretical mechanics, but from that of the practical designer of machinery. It is intended to give him a general survey of the possible mechanisms, to show their interrelations and transformations, the effects of changed dimensions, and so on, and to illustrate the ways in which they may be applied. Volume I is confined to 4-link chains, which are discussed comprehensively. In this new enlarged edition all the illustrations are now in a separate section at the back instead of being interspersed throughout the text as before.

PRINCIPLES OF RADIO. By Keith Henney and Glen A. Richardson. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 6th edition, 1952. 655 pages, diagrams, charts, tables, 8¹/₂ by 5³/₄ inches, cloth, $5.50. Many changes have taken place in radio in the seven years since the previous edition. In view of the changes the authors have revised and rewritten much of the text and have changed the problems and illustrations, but the aim of the work remains the same—to present the material so clearly that the book can be used by those who must study radio without the aid of a teacher.

PROCEEDINGS OF A SECOND SYMPOSIUM ON LARGE-SCALE DIGITAL CALCULATING MACHINERY. (Annals of the Computation Laboratory, Harvard University, Volume 25). Jointly sponsored by the Navy Department, Bureau of Ordnance, and Harvard University at the Computation Laboratory, September 13–16, 1949. Harvard University Press, Cambridge, Mass., 1951. 393 pages, tables, diagrams, charts, illustrations, 10³/₄ by 7³/₄ inches, cloth, $8. Of the 40 papers presented at the several sessions of the symposium, those of the first two sessions are devoted to discussions of recent developments in computation machinery. The next four groups are concerned with current applications, and include papers on numerical methods and on computational problems in physics, aeronautics, applied mechanics, and the economic and social sciences. The volume closes with a discussion of the future of computing machinery.

PROCEEDINGS OF THE THIRD BRITISH ELECTRICAL POWER CONVENTION. (Brighton, England, June 18–22, 1951.) Published by the convention, 16, Stratford Place, London, W.1, England, 1951. 280, Lxxip., illustrations, diagrams, charts, tables, 8³/₄ by 5³/₄ inches, cloth. The papers presented at the meeting, that are recorded herein, are: Electronics in Industry; Electricity as a National Asset—Its Uses and Application; A Survey of the Refrigeration Industry; and Electricity—A Factor in Social Progress.

SHORT-WAVE RADIATION PHENOMENA. By August Hund. McGraw-Hill Book Company, 330 West 42d Street, New York 18, N. Y., first edition, 1952. Two volumes, 1,382 pages, diagrams, tables, charts, 9¹/₄ by 6¹/₄ inches, cloth, $20 (set). Applying to frequencies between 30 megacycles and the highest in practical radio use today, this 2-volume set provides a comprehensive discussion of the useful applications of short-wave radiation phenomena, as well as both standard and recently developed propagation theory. It begins with fundamental concepts and relations of currents and electromagnetic fields, and continues with detailed treatments of electromagnetic theory, wave propagation, transmission lines and networks, unobstructed space radiation, radiation in the presence of electromagnetic obstructions, electromagnetic diffraction, wave guides, and cavities. The 80-page index provides a detailed approach to the text.

SHORT-WAVE RADIO AND THE IONOSPHERE. By T. W. Bennington. Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S. E. 1, England, second edition, 1950. 138 pages, illustrations, charts, tables, diagrams, 8³/₄ by 5³/₄ inches, bound, $2.50. Intended for those having a limited technical knowledge, this small volume covers the fundamentals of long-distance radio communication, describes the formation and structure of the ionosphere, and discusses characteristics, variations, and forecasting. Special reference is made to everyday professional and amateur problems of short-wave transmission and reception.

SYMPOSIUM ON BULK SAMPLING. Presented at the 54th Annual Meeting. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. (Special Technical Publication Number 114), 1951. 65 pages, charts, tables, 9 by 6 inches, paper, $1.75. The papers included in this symposium are concerned with the problems of sampling materials that occur in bulk form or packages with the aim of estimating measurable characteristics with controllable precision. Both engineering and statistical aspects are dealt with. Three of the six papers are on coal sampling.

TENSOR ANALYSIS. Theory and Application (Applied Mathematics Series). By I. S. Sokolnikoff. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1951. 335 pages, diagrams, 9¹/₄ by 6 inches, bound, $6. Tensor theory is first developed without reference to applications, covering linear transformations, matrices, and the algebra and calculus of tensors. Subsequent chapters demonstrate its application to geometry, mechanics, relativity, fluid dynamics, and elasticity, including certain aspects of the deformation of plates and shells. The book is intended to be of interest and use to mathematicians, physicists, and engineers.

TRANSMITTING VALVES. The Use of Pentodes, Tetrodes, and Triodes in Transmitter Circuits. By J. P. Heyboer and P. Zijlstra. N. V. Philips Gloeilampenfabrieken, Eindhoven, Netherlands, 1951. 284 pages, tables, charts, illustrations, diagrams, 9¹/₄ by 6 inches, bound, $6.25. The various aspects of transmitting tubes, as amplifiers, modulators, oscillators, and frequency changers, are successively presented in considerable detail but with a minimum of mathematics. The general technology of transmitting tubes and their classification are considered briefly in the first two chapters. The book purposely is limited to the treatment of tubes in which the transit time is of minor importance.

DER WÄRME- UND KÄLTESCHUTZ IN DER INDUSTRIE. By J. S. Cammerer. Springer Verlag, Reichpietschufer 20, Berlin W 35, Germany, third edition, 1951. 360 pages, illustrations, diagrams, charts, tables, 9¹/₄ by 6¹/₄ inches, bound, DM 36. A concise account of present knowledge of heat-insulation practice. The first section discusses the theoretical principles involved, gives the numerical values of the more important physical magnitudes needed by the engineer, and describes the properties of various insulating materials and the methods of measurement used. The second section deals with the calculation and use of insulating equipment and materials.

WASSERBAU. Teil 1, Der FLUSSBAU. (Technische Handbucher für Baupraktiker, Band 2, Teil 1). By J. Duhm. Verlag Georg Fromme and Company, Vienna, Austria, 1951. 491 pages, illustrations, diagrams, charts, tables, 8¹/₂ by 6 inches, paper, $6.25. Based on work done at a Swiss water experiment station, this book, the first part of a set on applied hydraulics, is concerned with river engineering. Following a review of hydrological fundamentals, procedures used in hydrometric studies are discussed. The flow of water in natural beds, its use as a source of power, and its control are all considered. Canal construction, the design of banks, and the strengthening and construction of dams all are dealt with.

THE WELDING ENCYCLOPEDIA. 13th edition revised and re-edited by T. B. Jefferson. McGraw-Hill Publishing Company, Inc., 330 West 42d Street, New York 36, N. Y., 1951. 1,008 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, simulated leather, $7.50. From abrasion to zirconium this standard reference work covers all terms relating to the broad field of metal joining and cutting by application of heat, including heat-treating processes and other allied subjects. Photographs, line drawings, graphs, data tables, and equilibrium diagrams are used extensively to illustrate or simplify the text. Pertinent codes, standards, and specifications are appended, and there is a 90-page list of trade names with descriptive information. The volume has been revised throughout in accordance with current practice.

## PAMPHLETS • • • • •

**The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.**

**An Adhesive Tape-Resistor System.** A complete description of developmental work done by the National Bureau of Standards on an adhesive tape-resistor permitting close control of resistance values. The tape-resistor, a carbon-film resistor in the form of an adhesive tape, covers a range of 10 ohms to 10 megohms. The use of asbestos paper tape and silicone resin binder results in a resistor capable of operation up to 200 degrees centigrade. Detailed information is given on production of the resistors and on equipment and materials needed. Description is included of the ovens, switching equipment, and recorder for making load-life tests. 83 pages, 32 illustrations. 30¢. Available from the Government Printing Office, Washington 25, D.C.

**The Properties of Magnesium Alloys Fabricated From Atomized Powder.** Prepared by Dow Chemical Company for the United States Air Force, this report describes a new alloying process which consists of mixing atomized magnesium powder with powder of the alloying metals and extruding the mixture. The powder-extrusion process results in alloys having higher strength than alloys of the same composition prepared by extrusion of billets. Also said to make possible new alloy compositions not obtainable by the melting and casting process, and these new alloys are said to provide alloys of greater strength, improved corrosion resistance, and better fabrication characteristics. 445 pages. $9.00 in microfilm. Available from the Library of Congress Photoduplication Service, Publication Board Project, Washington, D.C.

**NEMA Standards for Automatic Circuit Reclosers.** Deals with automatic reclosers which are self-contained devices for automatically interrupting and reclosing an a-c circuit. Specific information is given concerning the rating, manufacturing, and testing of such circuit reclosers, and a separate section of the book gives instructions for installation, operation, and maintenance. $2.00 per copy. Publication Number *SG13-1952*. Available from the National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

**Metal to Nonmetallic Brazing.** A summary of the results of a series of experiments on the brazing of both metals and nonmetallic materials with active metals. This brazing technique has been carried out in controlled atmospheres and vacuum with the use of fluxes. It should make possible better manufacturing techniques for the electronic industries and better cutting tools for metal working shops. 20 pages, including diagrams and tables. $2.00 in microfilm, $3.75 in photostat. Order from the Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D.C.

# INDUSTRIAL NOTES . . . .

**Sylvania Expansion Plans.** Sylvania Electric Products, Inc., has announced plans for a 50,000-square-foot factory building to be erected in the York, Pa., area, which will be used for the fabrication of metal parts and operated as a unit of Sylvania's parts division. Charles E. Schell will act as manager when the plant is completed at the end of the year. The company has also leased warehouse and office space in a new building at 3466 East Marginal Way in Seattle, Wash., that will serve as the headquarters for sales and service operations in the Pacific Northwest region.

**Acme Opens Two Canadian Branches.** Acme Electric Supply, Limited, has opened branches in Calgary and Edmonton, Alberta, Canada. R. W. Brews will be in charge of the Calgary office and A. W. Cook will be in charge of the Edmonton office.

**Secretary and Associate Secretary of G-E Elected.** Ray H. Luebbe has been elected Secretary of the General Electric Company and will continue as Vice-President and general counsel; and Wayne H. Perry, formerly administrative assistant to the president of the General Electric Company, has been elected associate secretary and will be in charge of operations of the company's corporate services division with headquarters in Schenectady, N. Y.

**Beedle Assistant Vice-President of Raytheon.** John H. Beedle has been elected an assistant vice-president of the Raytheon Manufacturing Company.

**Dr. Schwarz Joins Radiation Counter Labs.** Dr. Friedrich Schwarz has joined Radiation Counter Laboratories, Inc., as director of mechanical and design engineering. Dr. Schwarz was brought to this country by the late General Patton from Germany and employed by the United States Government at various rocket installations for the past 5 years.

**Leeds and Northrup Plans Expansion.** The Leeds and Northrup Company has purchased a 125-acre tract of land in North Wales, Pa. They plan to move certain operational or laboratory units from the main plant in Philadelphia, Pa., to the new site.

**Matthews Retires From Kodak.** Irving C. Matthews, research chemist for Eastman Kodak Company for almost 34 years, has retired.

**New Consulting Firm.** A consulting partnership has been formed at 400 Western Union Building, Boston 10, Mass., under the name of the Pi-Square Engineering Company. Dr. Henry M. Paynter, one of the partners, is assistant professor of hydraulic engineering at Massachusetts Institute of Technology; the other partner is George A. Philbrick, Chairman and President of Philbrick Researches, Inc.

**Westinghouse Appointments.** James R. Weaver has been named assistant to T. I. Phillips, Vice-President in charge of manufacturing for Westinghouse Electric Corporation; and W. W. Bryant has been made defense products administrator for the company's elevator division. James S. Wallwork will replace Mr. Bryant as acting eastern district application engineering supervisor.

**Engineering Research Names Two Directors.** Engineering Research Associates, Inc., has appointed Dr. Sidney M. Rubens as director of physics, and Dr. Arnold A. Cohen as director of telecomputing systems development.

**Minneapolis-Honeywell Sets Up Research Center.** A new research center has been established in Philadelphia, Pa., by the valve division of the Minneapolis-Honeywell Regulator Company. An important phase of the research activity will be the determination of the suitability of substitute valve materials proposed to relieve the critical alloy situation.

**Allis-Chalmers Appointments.** Alfred L. Morningstar has been named assistant application engineer in the control section of the Allis-Chalmers Manufacturing Company, and Thomas F. Finley and George N. Lester have been made assistant engineers—in the switchgear section and at the Boston works, respectively.

**Air Reduction Elects Vice-President.** George V. Slottman has been elected a Vice-President of the Air Reduction Company, Inc. He will also continue as the company's director of research and engineering.

**Hagen Corporation Establishes Aeronautical Division.** Hagan Corporation, combustion and chemical engineering firm, has established a new aeronautical and special products division. Initial work of the new division will be the development of controls in the fields of aeronautical engine and guided missile testing, wind tunnels, atomic power plants, centrifugal blowers, and force measuring systems. William F. Waina has been made manager of the division.

**AiResearch Names Chief Engineer.** S. K. Anderson has been promoted to chief engineer of the AiResearch Manufacturing Company.

**Steward Appointments.** The D. M. Steward Manufacturing Company has appointed R. N. Palmquist as district representative in charge of their New York–New Jersey office at 1922 Raymond Commerce Building, Newark 2, N. J.

(*Continued on page 32A*)

## THIS PORCELAIN REPLACED A PIECE OF CAST IRON

**Remember** when open-type fuse cutouts were made with a cast iron base carrying two pin-type distribution insulators to which were clamped a fuse switch assembly?

Because of the development by Lapp of such a part as this porcelain "post," design and construction of present-day "standard" fuse cutouts have been made simpler, less expensive and more dependable.

For here is a porcelain part designed to utilize the known strength of porcelain, to perform a mechanical as well as an electrical duty. In addition to insulating the terminals of the switch from each other and from ground, it performs the mechanical duty of a supporting member for the entire mechanism.

This is one example of many Lapp-originated or Lapp-built improvements which depend on sound use and sound construction of porcelain parts.

At Lapp exists a firm conviction that porcelain is more than a fragile insulating material which must be used timidly. We have learned, and repeatedly proved, in performance records, that it can be used in such a way as to take advantage of its known great strength and permanence to improve *mechanical and electrical* efficiency and dependability.

To manufacturers of electrical equipment utilizing porcelain insulation, we offer our engineering and production know-how. To users of high voltage insulators, we offer a product with a proved margin of operating security, of long life, of low upkeep and maintenance. Lapp Insulator Co., Inc., Le Roy, N. Y.

**Lapp**

(*Continued from page 16A*)

C. L. Greenslade has been made the Chicago district representative.

**Du Mont Promotes Radford.** Lewis C. Radford, Jr., has been appointed eastern district sales manager for the television transmitter division of Allen B. Du Mont Laboratories, Inc. Mr. Radford will supervise television transmitter sales and engineering services of the entire eastern district from Maine to Florida.

**Sola Opens Boston Office.** The Sola Electric Company of Chicago, Ill., has opened a branch office for lighting and luminous tube transformer sales in Boston, Mass., with John B. O'Donnell as sales representative.

**Alcoa Appointment.** The Aluminum Company of America has made Frederick C. Stakel advertising manager.

**Rome Cable Opens New Office.** The Rome Cable Corporation has opened a new sales office at 1207 Grand Avenue, Kansas City 6, Mo., to service the Kansas-Missouri area. R. R. Davis has been made branch manager.

## NEW PRODUCTS • •

**Third-Rail Conductor System.** The Electric Service Manufacturing Company, 17th and Cambria Streets, Philadelphia 32, Pa., has announced development of a new aluminum (third-rail) conductor system with safety enclosures for powering moving cranes of all types, ore bridges, and allied materials-handling equipment. Called the Keystone system, it makes obsolete the need of improvising structural shapes such as steel railroad rails or steel or copper angles, tees, bars, or wire to feed power moving equipment. The Keystone system offers a design capacity of 1,000 amperes in a conductor weighing 1/20 that of steel rail–copper booster combinations. It can be used for control and medium amperage conductors and can be applied in parallel to handle currents two or more times its normal rating. The absence of arcing permits safe high-voltage operation (4,160 volts is being used on several current applications). Particularly desirable on long a-c installations because of its noninductive nature, aluminum in the Keystone system may be spaced on close centers to achieve low reactance drops previously obtainable only with copper systems. More complete information is available from the company.

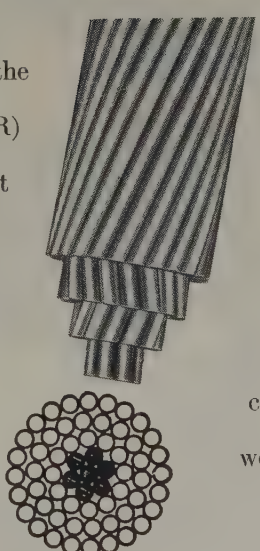
**Rapid-Start Fluorescent Lamp.** Development of a new type of fluorescent lamp which starts quickly without the aid of external starters has been developed by the General Electric Company. Named "Rapid Start," the new lamps are to be used with especially designed ballasts, and are intended only for new lighting systems. These lamps differ from the

(*Continued on page 34A*)

*The Swedes know how to make conductors . . .*


# stronger*

One of the reasons why Feral Cable (Swedish-made ACSR) is in demand all over the world is its great strength combined with its low weight. Feral Cable is 30% lighter and at the same time 30% stronger than copper cable. These factors also contribute to make the installation of Swedish-made ACSR cheaper.



In round figures the saving in costs will amount to about 40%.

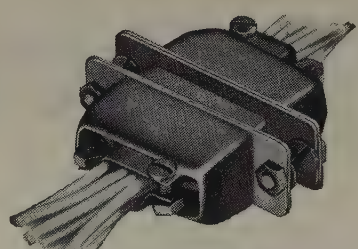
The Svenska Metallverken Feral Cable plant is being enlarged in order to make it possible to meet the enormous demand for ACSR today. At the turn of the year 1952–53 the capacity is estimated to equal that of the world's largest manufacturers of ACSR.

## *FERAL ACSR *cable*

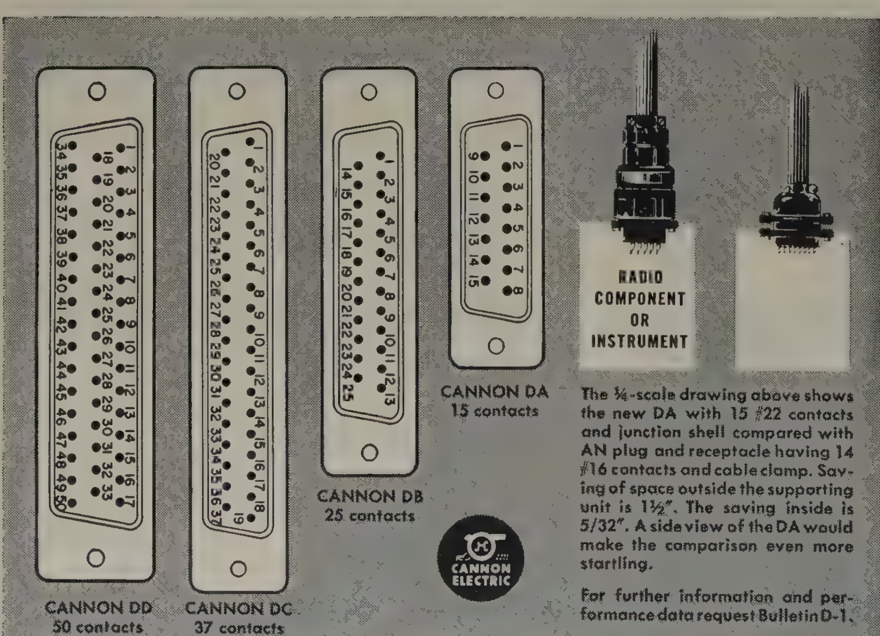
## AB SVENSKA METALLVERKEN

SALES OFFICE: STOCKHOLM 16, SWEDEN










(*Continued from page 32A*)

conventional preheat types in two respects: they employ a complex, triple-coiled cathode, which serves to conduct electricity from the wires to the gas; and a water-repellent coating to insure reliable starting under high-humidity conditions. Further details are available from the General Electric Company, Nela Park, Cleveland 12, Ohio.

**Magnetometer.** The model *101* magnetometer announced by the Laboratory for Electronics measures magnetic field strength by using the principle of nuclear resonance. An oscillatory magnetic field is provided by means of a coil surrounding a sample which permits measurement of proton resonance and the nuclear resonance of lithium ($Li^7$). The coil is part of an oscillator which is so designed that its level of oscillation drops with an increase in circuit losses, such as may be introduced by nuclear resonance in the sample material. This resonance can be easily viewed on an oscilloscope. The range of field strength measurements is from 300 gauss to 25,000 gauss, covered by proton and lithium resonances. This field strength range is covered by a frequency spectrum of 1.18 to 34 megacycles. Means are provided for varying the width of modulation sweep from 1.6 to 16 gauss. The equipment's use is limited to the measurement of magnetic fields whose homogeneity is at least one part in 500 for proton resonance and one part in 5,000 for lithium resonance over the dimensions of the sample to be detected. The Laboratory for Electronics, Inc., 75 Pitts Street, Boston 14, Mass., will supply any additional information desired.

**Railway Car Lighting Generator System.** A new type of railway passenger car lighting generator system developed by the Bogue Railway Equipment Division, 52 Iowa Avenue, Paterson, 3, N. J., makes use of a waterproof high-frequency a-c generator in lieu of the conventional axle-driven d-c generator. The a-c output of the high-frequency generator is converted to direct current by a selenium rectifier and the potential and flow of electric energy is automatically regulated by a magnetic amplifier. Designed to reduce maintenance costs, the new generator contains no commutators, brushes, rotating windings, or polarity reversing devices. Also, reverse current relays and slip rings are not needed. D-c electric power required for battery charging is produced by rectification of the high-frequency output of the axle-driven generator. An automatic magnetic-amplifier voltage and current regulator determines the amount of electric energy required for car lighting and other loads as well as for battery charging. The regulator automatically controls both voltage and current. This new system is manufactured in capacity ratings ranging from 1 kw for railway caboose applications to 50-kw models for railway dining car applications. Additional details may be obtained from the company.

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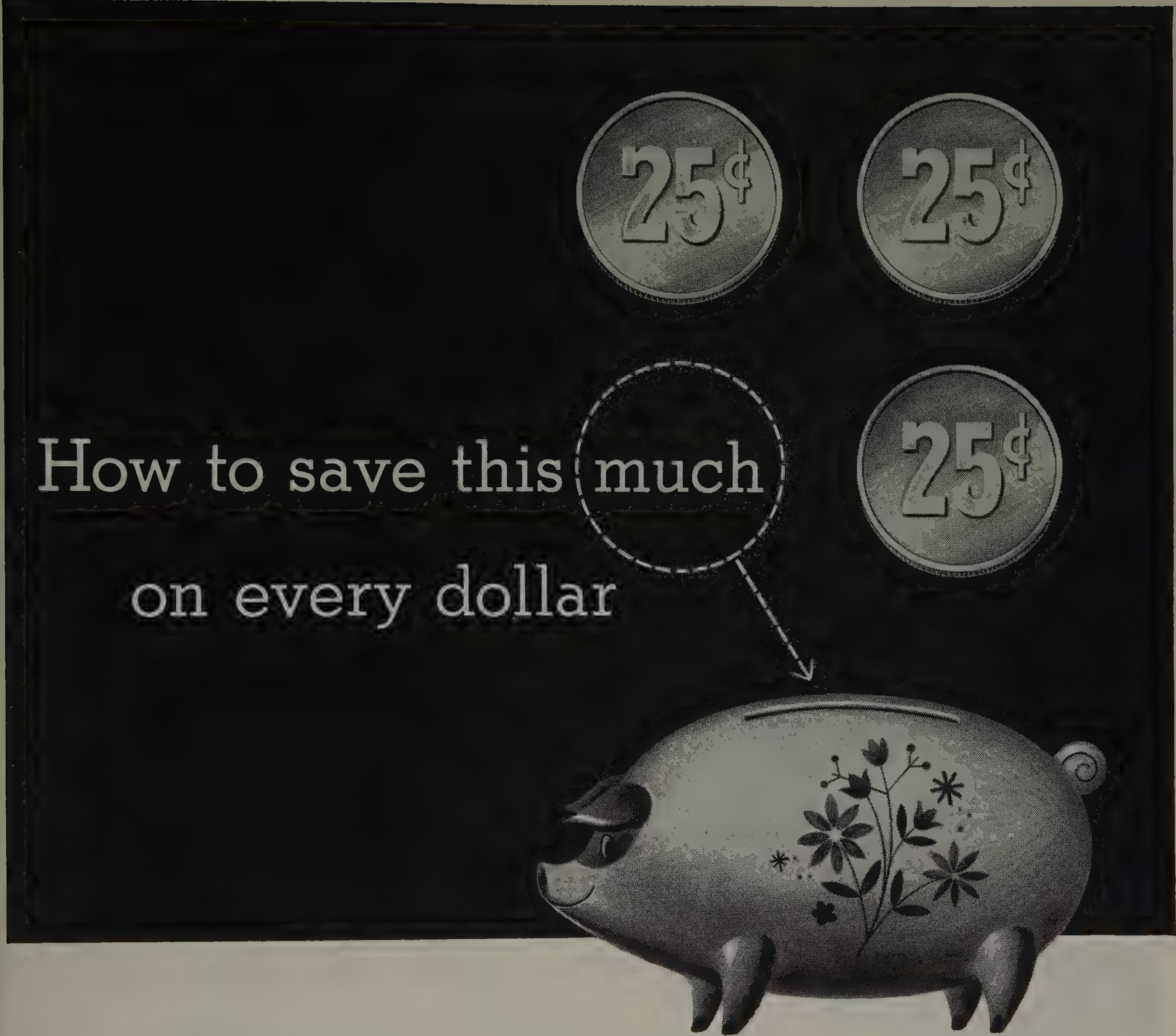



If you use Kaiser Aluminum Weatherproof Conductor on your next installation you'll save *up to 25%*. Here's why:

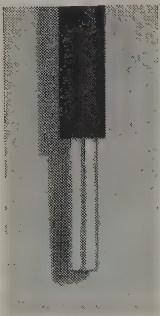
Aluminum conductor costs less than copper, so your initial expense is less.

Aluminum has about half the weight of copper, so handling is easier—faster installations are possible.

And Kaiser Aluminum Weatherproof Conductor's light weight and small diameter assure lower wind- and ice-loadings, lower tensions on house and pole. Neoprene or polyethlene covering resists moisture, abrasion, fungi—will not festoon. So maintenance costs are reduced.

*Act now!* Give immediate consideration to the savings and advantages of Kaiser Aluminum Weatherproof Conductor for both *service drops* and *secondary distribution lines.* Send for free booklet giving complete engineering data on new Kaiser Aluminum covered conductor—both weatherproof line wire and self-supporting Triplex.

Call or write Kaiser Aluminum offices in principal cities, or our distributors: General Electric Supply Corporation, Westinghouse Electric Supply Company, Line Material Company, Mine Smelter and Supply Company, Tafel Electric and Supply Company, Kaiser Aluminum & Chemical Sales, Inc., Oakland 12, California.



**TYPICAL COST SAVING on a 100-ft., 3-wire service**

| | MEDIUM HARD DRAWN NO. 6 SOLID TRIPLE BRAID COPPER | NEOPRENE-COVERED NO. 4 SOLID ALUMINUM CONDUCTOR |
|---|---|---|
| Conductor . . . . | $11.14 | $ 8.70 |
| 3 Split Bolts at Pole . | .75 | .84 |
| 3 Connectors at House | .21 | .36 |
| Cost of Wire Holders . | .81 | .81 |
| | $12.91 | $10.71 |

A saving of 17%, **plus** lower installation costs!

# Kaiser Aluminum

**Setting the pace—through quality and service**

(*Continued from page 34A*)

**Resonant Reed Relay.** A reed relay is an electromechanical device which responds to an alternating signal having frequency and amplitude values that lie within specified bands. Transmission of a number of signals over a single circuit is greatly simplified, and their use may be extended to all types of communication circuits including radio and carrier systems. In a typical application a control function is used to turn on or off a source of low-frequency signal (50 to 500 cycles per second). The signal is transmitted either on a wire line or as a modulated carrier to some remote location where it operates a reed relay to indicate the control function at that point. Since each reed relay will respond to a narrow band of frequencies, it is possible to operate a number of relays simultaneously by making use of an equal number of source generators arranged so that none of the operating frequency bands overlap. In the range 200 to 500 cycles it is possible to operate up to 16 channels with no interference between channels. If a single receiving relay is used for each function, it is possible to handle 16 control functions. Where $n$ relays are used, the number of control functions which can be handled is equal to the number of combinations of 16 relays taken $n$ at a time. Where 4 relays are used, 1,820 control functions can be handled. For full details, request bulletin *33–7* from the James G. Biddle Company, 1316 Arch Street, Philadelphia 7, Pa.

**Vacuum Gauge.** A new gauge, type *PHG-09*, which covers a range of 8,000,000:1 on a single meter from a single pickup has been announced by the Vacuum Equipment Department, Distillations Products Industries Division, Eastman Kodak Company, Ridge Road West, Rochester 3, N. Y. The gauge can be used to read vacuums from 0.50 millimeter to $10^{-7}$ millimeter mercury. The all metal pickup tube which handles this range works on the glow discharge principle. In the tube, permanent magnets provide a field which lengthens the electron paths into tight spirals that give high ionization per electron, with a cascade effect. Having no filament to burn out, the new tube can be operated at full atmosphere without damage. Also, the circuit is insensitive to fluctuations in line voltage. Because the magnets are external to the ionization chamber, there is no problem involved with outgassing the magnets or removing stray iron particles. The tube is automatically self-cleaning because, when operated at higher pressures in the lowest sensitivity range, it rids itself of deposited film. Further information may be obtained from the company.

**Labmarker.** The Labmarker, developed by Berkshire Laboratories, is a wave-shaping device for producing time marks in cathode-ray oscillography. A sinusoidal input is converted by the instrument into a series of unidirectional pulses which may be displayed directly on the face of a cathode-ray tube by connecting the output

(*Continued on page 52A*)

# ROCKBESTOS A.V.C.®
# CARRIES 32% GREATER LOAD

**YET BOTH ARE THE SAME SIZE**

## *Compare A.V.C. with Type RH in a 250 MCM size**

Size for size A.V.C. has a HIGHER AMPERE RATING

Hi

YOUR BEST BUY

- you use 2½" conduit for both
- you use the same size fittings and lugs
- you have the same installation costs
- BUT Type RH carries only 224 amperes whereas higher-rated A.V.C. carries 296 amperes—a 32% increase in capacity.

For more efficient current-carrying capacity, always specify Rockbestos A.V.C. Write for the booklet "Cut Current Carrying Costs."

*From Chapter X—National Electrical Code—3 conductors in conduit—40°C-104°F.

**ROCKBESTOS A.V.C.**

ROCKBESTOS PRODUCTS CORPORATION NEW HAVEN 4, CONN.

NEW YORK CLEVELAND DETROIT CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES OAKLAND, CAL.

(Continued from page 38A)

of the Labmarker to the vertical input of an oscilloscope. Timing marks consisting of short breaks in the oscilloscope trace are obtained by connecting the output of the Labmarker to the $z$ input terminals of the oscilloscope. The instrument may be plugged into the terminals of an oscillator; no other power source is required. Model *1-U* has two pairs of output binding posts, one giving positive pips, the other for negative pips. If both outputs are used simultaneously, the positive and negative pips are 180 degrees apart. Berkshire Laboratories, 540 Beaver Pond Road, Lincoln, Mass., will supply any further details.

**New Capacitors.** A metal-encased tubular ceramic capacitor developed by the Herlac division of the Sprague Electric Company, 15 Marshall Street, North Adams, Mass., extends the capacitance range available to circuit designers at rated voltages of 500, 1,000, and 1,500 volts direct current. Their stability makes possible a controlled capacitance tolerance within ± one per cent and temperature coefficient tolerances within ±10 parts per million per degree centigrade. For less critical applications, the usual tolerance on temperature coefficient is ±30 parts per million or ±15 per cent of the nominal temperature coefficient, whichever is greater. Bulletin *607*, which is available from the company, contains additional information.

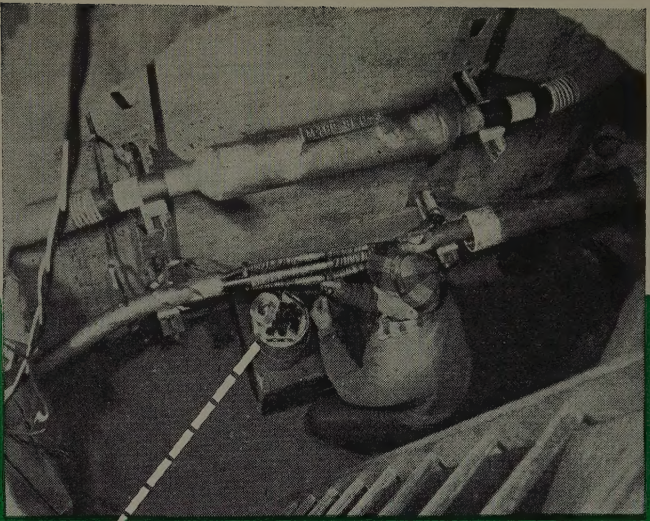
**Flamometer.** The Flamometer is a new instrument designed to detect, amplify, and indicate electric signals in the audio-frequency range, generated by turbulent flames. It consists of a detecting probe (ceramic tip supported by a metal rod) and an electric circuit. No significant signal is registered unless the probe is in an actual flame zone which is both ionized and turbulent. Response time is of the order of a millisecond. The signal from the probe is fed to an electronic amplifier with gain control, which allows the instrument to be used in different types of flames. The amplifier output can be read from the meter on the instrument panel; can drive a 0–1 milliampere pen recorder; the signal can be followed on an oscilloscope; or can be used to actuate relays or a servomechanism. The first two stages of the amplifier are shock-mounted to minimize microphonic interference, making the instrument a useful aid for studying combustion and flame propagation. Further information is available from the Phillips Petroleum Company, Instruments Division, Bartlesville, Okla.

## TRADE LITERATURE

**Lighting for Industry.** "Lighting for Industry" is a new 96-page handbook published by the Holophane Company, Inc., 342 Madison Avenue, New York 17, N. Y., which contains general engineering information on the principles and eco-

(Continued on page 56A)

An important splice in progress on a 3/c, 500 MCM, 26,400 V shielded paper-lead feeder cable for Public Service Electric and Gas Company's new Warren Point Substation at Fairlawn, N. J.



# Public Service Electric and Gas Company insures continuity of service *with* NATVAR Splicing Kits

Veteran splicers in the Underground Department like Natvar splicing kits, because they provide exactly the right number of rolls of v.c. tape cut to proper lengths and widths, and exact quantities of other materials required for the job. Engineers and foremen like the kits because they give close "quality control" of the splicing operation, with a minimum of waste and spoilage.

Public Service is working around the clock to provide adequate service for one of the fastest growing areas in the country. Long range planning demands that additional facilities to meet the increasing load be built on a permanent basis.

For this reason, extreme care is exercised in the selection of equipment and materials for the expansion program. Natvar splicing kits, made up in units for various sizes and types of cable, speed underground splicing because of their convenience and insure uninterrupted service because of the uniformly high quality of the materials.

All Natvar flexible insulations have excellent physical and electrical characteristics, and are dependably uniform, no matter where or when purchased. They are available either from your wholesaler's stock or direct from our own.

## Natvar Products

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Slot insulation
- Varnished tubing and sleeving
- Varnished identification markers
- Lacquered tubing and sleeving
- Extruded plastic tubing and tape
- Extruded plastic identification markers

*Ask for Catalog No. 22*

**NATVAR CORPORATION**

FORMERLY THE NATIONAL VARNISHED PRODUCTS CORPORATION

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CABLE ADDRESS NATVAR: RAHWAY, N. J.

203 RANDOLPH AVENUE • WOODBRIDGE, NEW JERSEY


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nomics of lighting related to specific industrial areas. The handbook may be obtained upon request.

**Connectors.** Recommendation charts that detail the advantages of each connector type for specific applications in tapping and splicing aluminum conductor in overhead distribution are featured in catalogue *AL53*, "Connectors for Aluminum in Overhead Distribution." The 32-page catalogue is available from Burndy Engineering Company, Inc., Norwalk, Conn.

**Meter Guide.** A 52-page pocket guide (*GET-2376*) for the selection and installation of watt-hour and demand meters, along with wiring diagrams of the various meters used in most systems, may be obtained from the General Electric Company, Schenectady 5, N. Y.

**Circuit Breakers.** A complete study of type-AB circuit breakers is given in a new 35-page booklet, *B-5407*, which is available from the Westinghouse Electric Corporation, Box 2278, Pittsburgh 30, Pa.

**Radioactive Terminology.** A bulletin listing accurate standardized definitions of 58 of the most commonly used words in the radioactive measurement field may be obtained from the Radiation Counter Laboratories, Inc., Nucleonic Park, 5122 West Grove Street, Skokie (Chicago), Ill.

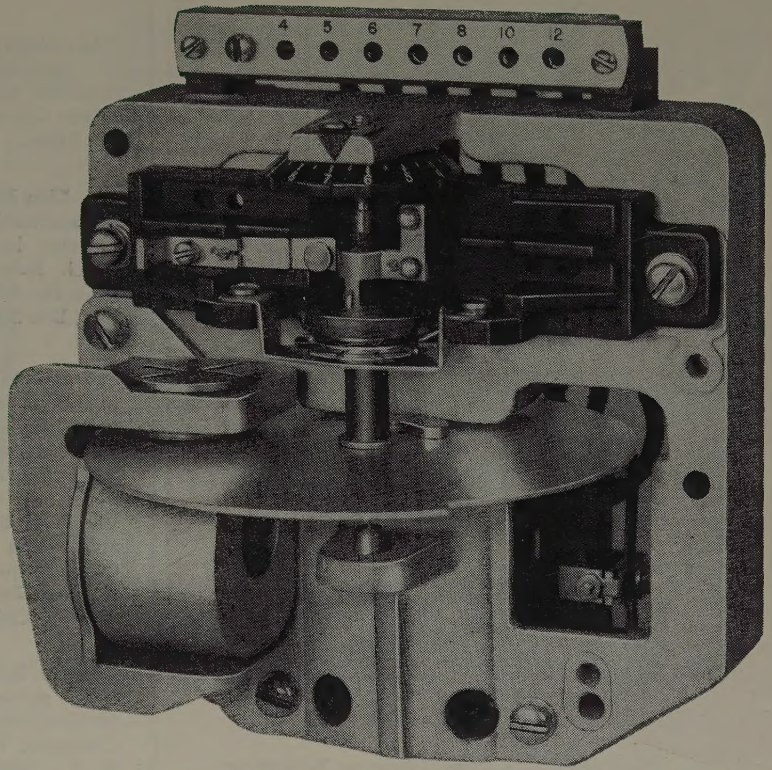
**Neoprene Facts.** The *Neoprene Notebook* is a monthly magazine containing facts about neoprene for the engineer. To receive the magazine regularly, send name, address, and title to the Rubber Chemicals Division, E. I. du Pont de Nemours and Company, Inc., Wilmington, Del.

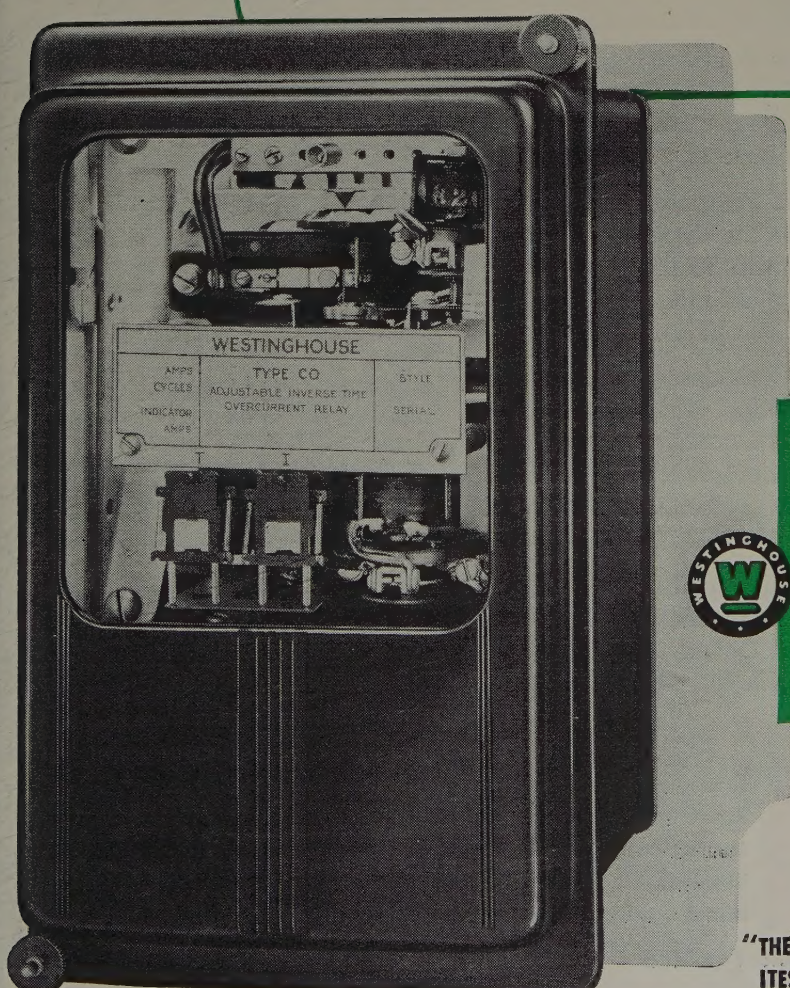
**Syncrogear Motor Movie.** A new movie in color and sound featuring the development and application of internally geared electric motors has been produced by U. S. Electrical Motors, Inc. The movie is directed at electrical and maintenance engineers who are desirous of learning how best to apply geared power and who want to fully understand the design and characteristics of motors in the geared classifications. A showing of this 20-minute film can be arranged by writing to U. S. Electrical Motors, Inc., Box 2058, Los Angeles, Calif.

**Steam Generator.** Bulletin *2000* describes in 26 pages the component features of the Preferred unit steam generator. The bulletin may be obtained from the Preferred Utilities Manufacturing Corporation, 1860 Broadway, New York 23, N. Y.

**Electron Microscope.** The Engineering Products Department of the RCA Victor Division of the Radio Corporation of America has issued a new brochure, *2R8195*, "The Electron Microscope at

(*Continued on page 64A*)



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# Westinghouse

## RELAYS

**"THE TYPE CO OVERCURRENT RELAY IS AVAILBLE IN FLEXITEST OR STANDARD RECTANGULAR PROJECTION CASE."**

(*Continued from page 56A*)

Work in Industry." Copies of the brochure are available by writing the Scientific Instrument Section, RCA Victor Division, Camden 2, N. J.

**Thermistors.** A 30-page catalogue (*TH-5*) describing Carboloy thermistors is available from the Carboloy Department of the General Electric Company, Detroit 32, Mich.

**Life-Line Motors.** Over 100 case histories of applications of life-line motors are depicted in a 35-page booklet (*B-4769*) which may be obtained upon request from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

**Correction Capacitors.** Catalogue *27* contains four separate sections, each dealing with specific types of capacitors: section 1 gives general information on power-factor correction capacitor applications and locations; section 2 details individual units; section 3 is devoted to rack-type assemblies; and section 4 lists pole types. Copies of the catalogue are available from the John E. Fast Company, 3125 North Crawford Avenue, Chicago 41, Ill.

**Hints on Babbitting Practice.** A booklet (*146*) published by Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y., outlines basic steps for the prevention of common bearing failures. "Hints on Babbitting Practice" covers everything from the choice of metal for a particular bearing application through the correct pouring practice to in-service maintenance. Copies are available upon request.

**Pressure-Sensitive Tapes.** Detailed information on characteristics, uses, and technical data for Permacel pressure-sensitive electrical tapes is provided in a catalogue offered by the Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago 6, Ill.

**Progressive Mechanization.** A new visual program aimed at boosting American productivity has been announced by the General Electric Company. Called "Progressive Mechanization," the program presents a consolidation of the principles of production technique and mechodology. The program consists of three basic parts: a 16-millimeter sound-color motion picture entitled "Motors in Industry," a 16-page manual (*GEA-5789*) designed to help management initiate its own program to improve its industrial processes; and a survey form and check list—a form for enumerating the machines and processes recommended for investigation and suggested areas for improvement. The entire presentation may be purchased outright from the General Electric Company at cost, or is available for single showings through any of the company's apparatus offices. For those who only desire a copy of the manual *GEA-5789*, it is available upon request from the General Electric Company, Schenectady 5, N. Y.